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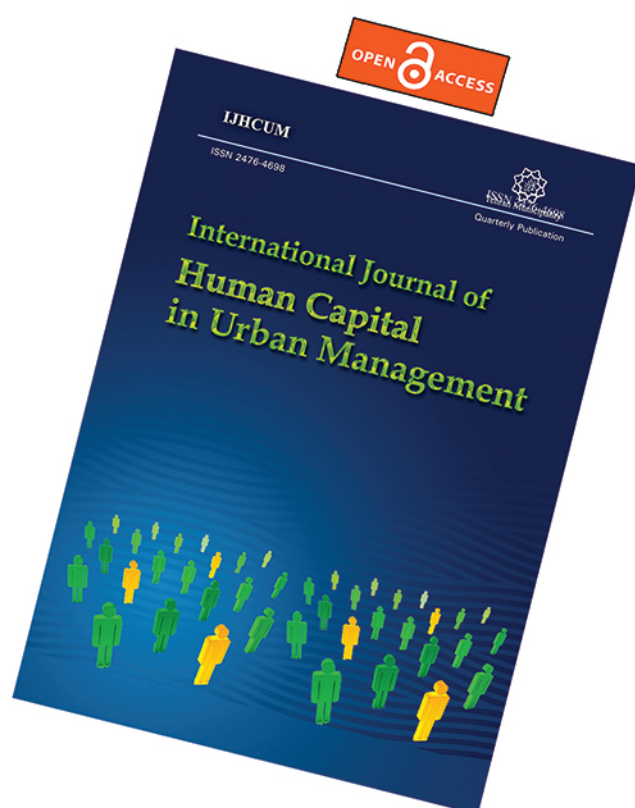
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ORIGINAL RESEARCH PAPER

Selected trace elements evaluation in soil from an urban farming area

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ABSTRACT

BACKGROUND AND OBJECTIVES: Urban farming makes a substantial influence on the household economy of the urban poor especially in developing countries. Urban soil the hot spot of urban farming is a natural sink for contaminants especially the trace elements derived mainly from anthropogenic activities. This study's aim was to quantify the concentrations of selected trace elements (Cr, Mn, Cu, Ni, and Zn) in topsoil (0-20 cm) and subsoil (21-50 cm) and to evaluate whether their concentration vary during dry and rainy season.

METHODS: Grid soil sampling method was used to collect soil samples and their total concentration was determined using a portable X-ray Fluorescence Spectrometer.

FINDINGS: The study revealed that the topsoil had higher concentration than sub soil. The topsoil concentration in mg/kg were 61.62, 4042.58, 30.82, 43.90 and 456.43 for Cr, Mn, Ni, Cu and Zn respectively. The subsoil concentration in mg/kg were 54.67, 3791.38, 30.32, 27.83 and 370.32 for Cr, Mn, Ni, Cu and Zn respectively. It also noted that concentration of the trace elements was higher during dry season than wet season but not significantly different ($P \geq .05$) for all the elements.

CONCLUSION: The study recommends that there is need to monitor levels of trace elements investigated in soil to ensure they do not reach detrimental levels.

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INTRODUCTION

Due to food shortages, food production in peri-urban areas is being broadly accepted as one of the basic urban occupations. In Kenya 29 % of urban households grow crops in towns (Ghosh, 2004). This practice of urban agriculture is aimed to increase food supply for health nourishment of consumers, employment and to improve environmental sustainability. To a large extent, urban farming utilizes solid and liquid waste resulting into effective waste management in cities and thus make cities green (Smit *et al.*, 2001). Irrespective of the locality of agriculture, be it in rural or urban, soil is a major resource to the environment and food production whereby it serves as the prime nutrient source for plants. Determination of soil quality is a first-rate measure of its fertility which makes it an economical way of maintaining nourished health plant leading to excellent crop productivity (Galuszka *et al.*, 2015). In an urban area this need is necessitated by the fact that rural environments are less polluted than urban areas. More so from the potentially toxic trace elements, due to their emissions from traffic and burning of fossil fuels for energy and manufacturing use (Mielke *et al.*, 2011). Different from soil in the countryside, natural conditions of soils in urban area undergo many changes as a result of human activities (Eghbal *et al.*, 2019). Such changes include high levels of trace elements in urban soils. Even Though such high levels may sometimes be attributed to the geology of the area, influence of anthropogenic activities that release trace elements in the environment, causing elevated content of trace elements in the soil is key (Ogunkunle *et al.*, 2017). The ever-growing number of industrial activities in cities of the developing countries has emerged to be one of the major contributors of soil pollution in urban areas (Fazel *et al.*, 2018). Hence making urban areas predominantly susceptible to trace elements pollution because of their accumulation in the soil. Soil as a constituent of the biosphere, is very important since it is a geochemical sink for pollutants, and it serves as a natural buffer regulating passage of chemical elements and other substances to the atmosphere, hydrosphere, and biota. Also, in food production, soil plays a major role thus making it a very essential component in the survival of humans. Therefore, mankind has a responsibility of maintaining the agricultural and ecological functions of soil (Kabata-

Pendias, 2011). Poor soil conditions affect food security directly and indirectly. Direct effects results in poor crop yield and a deprived nutritious standard of crop produce. Nutrient imbalance in soil, caused by shortage of some and toxicity resulting from excess of others, is a primary cause of poor yield in tarnished soils that has strong undesirable influences on crop harvest (Lal, 2009). In urban areas, soil, a component of the landscape, among other functions, has recreational and esthetical roles in gardens and parks that foster safeguarding of biodiversity. Unlike other soils, urban soil is prone to be used differently hence making its connection with other compartments of the ecosystem to vary. This is especially common due to presence of anthropogenic supplies that get mixed with it hence altering its functioning (De Kimpe and Morel, 2000). Anthropogenic activities, like industrial activities, traffic emissions, waste disposal and fuel combustion in urban areas, inevitably result in soil pollution (Ajmone-Marsan and Biasioli, 2010). These anthropogenic doings have caused contamination of the soils with various pollutants. Among the pollutants, potentially toxic elements (PTEs) and heavy elements are a main cause of concern. This concern becomes eminent as a result of the closeness of soil to humans and the roles soils play (Ajmone-Marsan and Biasioli, 2010). Due to environmental pollution in cities, urban farming poses food safety concerns and public health issues (Oka *et al.*, 2014). The environmental pollution is as a result of the locations of urban farming that are usually in areas of intense traffic concentration, industrial activity, and sewage effluents (Oka *et al.*, 2014). Further, for high yield to be realized, pesticides and fertilizers are less utilized in rural areas than urban areas. These coupled with intensive anthropogenic activities in urban farming areas, a weighty load on the quality of the soil is imposed (Zhao *et al.*, 2007). This notwithstanding, urban farming is greatly increasing in developing and developed countries around the world; however, pollution of urban farming products can exceed the permissible levels and result to human health risks due to dietary exposure to high levels of toxic trace elements, associated with soil pollution. (Ogunkunle *et al.*, 2017). This is generally because absorption of potentially trace elements by the plant on contaminated urban farms is one of the main and indirect routes of entry of trace elements to human food chains (Mahabadi, 2020) Hence, monitoring

and assessment of trace elements concentrations in the urban farming soils is an excellent way of understanding and evaluating ecosystem health. (Ogunkunle *et al.*, 2017) Assessment of this nature, more so that of trace elements, provides valuable knowledge on the trace elements contents that can indicate the health of the vegetation as well as the extent of contamination in the environment (Eghbal *et al.*, 2019). The aim of the study was to quantify the concentrations of selected trace elements (Cr, Mn, Cu, Ni, and Zn) in topsoil (0-20 cm) and subsoil (21-50 cm) and to evaluate whether their concentration vary during dry and rainy season. This study was done in Ruai, an urban area within Nairobi city County Kenya in 2018.

MATERIALS AND METHODS

Study Area

The study was carried out in Ruai ward, Ruai sewage area, which is in Nairobi East Kasarani constituency, Kasarani Sub County. The area is approximately 30 km east of Nairobi City Centre off Kangundo road (Fig. 1) and its geographical coordinates are 1° 18' 0" South, 36° 55' 0" East. (Opijah *et al.*, 2007). The

rainfall is bimodal with long rains occurring between March and May while the short rains are in August to November. The rainfall ranges between 750mm to 1500 mm, with a mean annual rainfall of 1250mm. The temperature varies from 17 °C to 27 °C. June and July are the months with lowest temperature while the hottest months are January and September with temperature from 25 °C to 27 °C. (Opijah *et al.*, 2007). The area is drained by Athi River and its tributaries which flow northeastwards and eastwards. Athi River has several seasonal tributaries which have water during the rainy seasons and immediately after, otherwise they are normally dry most part of the year. The geology of the area generally contains Nairobi volcanic sheltered by black cotton clay soils. The area is generally flat with Nairobi River at the north Eastern region of the area (Opijah *et al.*, 2007).

Selection of study site and sampling points

Domestic and industrial wastes in Nairobi city are transported to Ruai for treatment. These wastes have pollutants from the municipal drainage or the industrial drainage that are either dissolved in sewage water or attached to suspended matter. These pollutants eventually get into the treatment plant

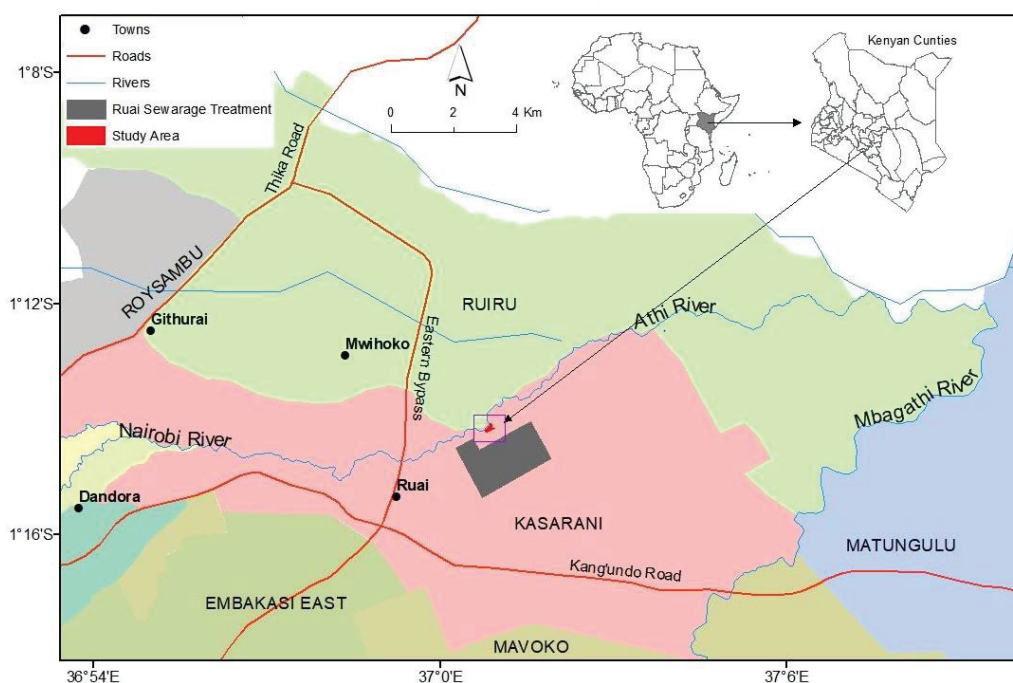


Fig. 1: Map of Nairobi showing Location of Ruai Sewage treatment plant in the study area.

and finally to the sludge. Therefore, the area was considered for the study because some potentially toxic trace elements are prone to be in the sewage sludge and consequently into the soil.

Sample Collection

A 50 m by 50 m grid was constructed over the site. 15 sampling points were identified within the area using grid soil sampling pattern according to Wollenhaupt and Wolkowski, (1994). At each sampling point topsoil (0-20 cm) and sub soil (21-50 cm) samples were collected with an auger from five cores within a 2-meter radius and pooled into two buckets, one for topsoil and the other for subsoil. The samples were then thoroughly mixed in the buckets using a trowel. About 50 g of the sample was subsampled into labeled plastic bags respectively to form a total of thirty soil samples. All the labeled thirty soil samples were individually sealed into polythene bags to avoid cross contamination and thereafter transported to the World Agroforestry (ICRAF) laboratories in Nairobi for preparation and analysis. Sampling and transfer of samples was done on the same day. Sampling was done during the dry and wet season.

Sample Preparation and analysis

Soil samples were air-dried, mechanically crushed using a stainless-steel roller and sieved through 2-mm sieves. About 10 grams was then subsampled by coning and quartering and further milled to attain a particle size of between 20 - 75 μm using a Retsch RM 200 mill (Retsch, Düsseldorf, Germany) automated milling machines. About 3g homogenized sample was loaded into special XRF cups made from 4 μm (0.16 mil) polypropylene XRF film free from

irregular surfaces and contamination. Elemental concentration of the loaded soil samples was done using Bruker Tracer 5i pXRF instrument (900F4473) with Rhodium tubes. The units had resolutions (full width height maximum, or FWHM) of 135 eV at the Manganese K-alpha line. Soil samples were analyzed with a voltage of 30 kV and a current of 50 μA for 60 seconds with filter (Ti 25 μm : Al 300 μm).

Data Analysis

Results obtained were collated and statistically analyzed using R Version 3.3.3. Soil elemental concentration between the seasons and depths were subjected to analysis of variance using R version 3.3.3. The variation in elemental concentration due to depth and seasons were subjected to t-test to test the difference between the seasons and depths.

RESULTS AND DISCUSSIONS

Trace elements in topsoil (0-20cm)

Chromium

The study revealed that the concentration of Chromium in topsoil (0-20 cm) showed variation during the study period (Table 1), the concentration ranged from 54 mg/kg to 77.5 mg/kg (Table 1). The mean concentration of Chromium in topsoil (0-20 cm) was 61.62 mg/kg. Levels of Chromium in soil has been reported to vary according to area and the degree of contamination from anthropogenic activities (Kabata-pendias and Henryk, 2001; Kamaludeen *et al.*, 2003). Another aspect that has been reported to influence level of Chromium in soil is the amount that has been removed through volatilization, surface runoff, leaching and Phyto-uptake. Due to farming coupled with irrigation of wastewater at the sampling location, variation of

Table 1: Concentration of the five trace elements of topsoil (0-20 cm) and subsoil (21- 50 cm) for both season from the fifteen plots.

Elements (mg/kg)	Cr		Mn		Ni		Cu		Zn	
	Topsoil (0-20 cm)	Subsoil (21-50 cm)	Topsoil (0-20 cm)	Subsoil (21-50 cm)	Topsoil (0-20 cm)	Subsoil (21-50 cm)	Topsoil (0-20 cm)	Subsoil (21-50 cm)	Topsoil (0-20 cm)	Subsoil (21-50 cm)
Mean $\pm$ SD	61.62 $\pm$ 6.14	54.67 $\pm$ 5.85	4042.58 $\pm$ 380.45	3791.38 $\pm$ 572.11	30.82 $\pm$ 1.21	30.32 $\pm$ 1.37	43.90 $\pm$ 12.05	27.83 $\pm$ 12.54	456.43 $\pm$ 71.61	370.32 $\pm$ 74.42
Range	54.00 - 77.50	47.00 - 74.00	3320.00 - 4752.50	2865.00 - 4627.00	28.50 - 33.00	27.50 - 32.50	22.00 - 69.00	9.50 - 68.50	363.00 - 590.00	271.50 - 567.50
P -value	< .001		.052		.140		< .001		< .001	

chromium concentration in soil is expected as was revealed in the study (Avudainayagam *et al.*, 2003). The mean concentration of Chromium from the study area (61.62 mg/kg) is slightly below what has been reported on a worldwide basis on Cr concentration in urban soil of 66.08 mg/Kg (Su, *et al.*, 2014). A study in Iran, revealed a mean concentration of 28.7 mg/kg that was much lower than what was found in the current study (Maleki *et al.*, 2014). Further, a study in Varanasi, India, reported a mean concentration of 56.3 mg/kg (Mishra and Tripathi, 2008).

Manganese

Manganese content of the topsoil (0-20 cm) depicted a concentration range of 3320.00 – 4752.00 mg/kg with a mean concentration of 4042.58 mg/kg (Table 1). The total concentration of Manganese in surface soil has been reported to vary greatly ranging from less than 7 mg/kg to more than 9000 mg/kg (Hooda, 2010). Most of the soil manganese is from the parent material and other minor sources include atmospheric deposition, irrigation water and the use of sewage sludge (Hooda, 2010). High manganese content is reported for soils over mafic rocks, soils from arid or semi-arid regions and soils rich in organic matter (Hooda, 2010; Kabata-pendias and Henryk, 2001). Fixation of organic matter in topsoils is the reason why it tends to accumulate more on top soils (Kabata-pendias and Henryk, 2001).

The observed levels of Manganese could be attributed to Manganese content of the parent material, fixation of organic matter and anthropogenic activities around the area that include Irrigation of wastewater and atmospheric deposition. The range of Manganese of 3320.00 – 4752.00 mg/kg is high compared with various ranges that have been reported from similar studies that include; a study on urban soil contamination conducted in the city of Novokuybyshevsk in Russia had a range of 125.7 mg/kg to 270.6 mg/kg (Galitskova and Murzayeva, 2016). A study in Penas Albas, Spain, revealed a concentration range of 751 mg/kg to 1850 mg/kg (Couce and Vega, 2015). Further, a study in Manaila, Romania, revealed a concentration range of between 161 mg/kg to 1258 mg/kg (Simona *et al.*, 2015).

Nickel

The mean total Nickel concentration was 30.82 mg/kg in topsoil (0-20 cm) with a range from 28.50 mg/kg

to 33.00 mg/kg (Table 1). Though the range is within the reported broad world-wide range of 0.2 mg/kg to 450 mg/kg, the concentration mean of topsoil was higher than the soil world calculated mean of 22 mg/kg (Kabata-pendias and Henryk, 2001). However, the study location being an urban area that has a high possibility of being contaminated, the concentration mean of Nickel is prone to be higher than its reported world calculated mean. Typically, the mean concentration of Nickel from contaminated urban soil has been reported to be 29.14 mg/kg (Su *et al.*, 2014). Nickel concentration mean of 30.82 mg/kg for topsoil was higher compared to the reported world mean of contaminated urban soils which is 29.14 mg/kg (Su *et al.*, 2014). This shows the location has been highly contaminated in the previous period or the background concentration level of Nickel was higher for the site. The likely sources of pollution could be the sewage sludge and industrial dust to the area. In a similar study done in India, it was observed that constant application of untreated and treated sewage water to the soil led to elevated concentrations of trace elements in the soil (Mishra and Tripathi, 2008). A similar study on urban soil contamination conducted in the city of Novokuybyshevsk Russia had a range of 16.5 mg/kg to 35.25 mg/kg (Galitskova and Murzayeva, 2016). A study in the city of Tabriz Iran, revealed a concentration range of 2.50 mg/kg to 72.50 with a mean of 38.73 mg/kg (Taghipour *et al.*, 2013).

Copper

Copper content of the topsoil (0-20 cm) showed a range concentration of 22 mg/kg to 69 mg/kg with a mean concentration of 43.90 mg/kg (Table 1). Copper typically accrues in the topsoil, a phenomenon explained by the bioaccumulation of the element and existing anthropogenic activities (Kabata-Pendias, 2001). Like other elements investigated, variation in total elemental concentrations of copper was revealed. This variation could be attributable to differences in parent materials and to local pedologic and anthropogenic influences (Towett *et al.*, 2015). The revealed mean concentrations of Copper from the study is above the reported world mean that vary from 13 to 24 mg/kg (Kabata-pendias and Henryk, 2001). Therefore, copper levels were high as per the findings of the study in comparison to other global findings. The high concentration of copper could be

attributed to particulates of copper that are released into the atmosphere by wind-blown dust and influence of other anthropogenic sources (Nazir *et al.*, 2015). A similar study on urban soil contamination conducted in the city of Novokuybyshevsk Russia had a range of 4.6 mg/kg to 27.75 mg/kg (Galitskova and Murzayeva, 2016). A study in the city of Tabriz Iran, revealed a concentration range of 13.17 mg/kg to 265.67 with a mean of 101.25 mg/kg (Taghipour *et al.*, 2013). A study in Varanashiindia, revealed a concentration range of 32.3 mg/kg to 123.6 mg/kg with a higher mean concentration of 77.8 mg/kg (Mishra and Tripathi, 2008). A study in China revealed a concentration range of 22.2 mg/kg to 93.0 mg/kg with a slightly lower mean of 42.4 as compared to the present study (Guo *et al.*, 2013)

Zinc

Concentration of Zinc of the topsoil (0-20 cm) exhibited a concentration range of 363.00 mg/kg to 590.00 mg/kg with a mean concentration of 456.43 mg/kg (Table 1). The overall Zn content of soils is reported to vary greatly with a reported range of 10 to 300 mg/kg (Haluschak *et al.*, 1998), while background levels of uncontaminated soils are 17 to 125 mg/kg on a world-wide basis (Kabata-pendias and Henryk, 2001). Anthropogenic sources of zinc are substantial to its elevated levels that majorly arise from industrial activities, waste combustion and steel processing. The world's Zn production is increasing, and manufacturing applications tend to scatter Zinc extensively in the environment, resulting to concentration levels that are above pre-industrial levels in soil, water and air. The mean content of Zinc of the site was high compared to concentrations recognized for soils on the globe (Kabata-pendias and Henryk, 2001) and soils from polluted urban areas (Su *et al.*, 2014). The high Zn content is a typical characteristic of contaminated sites whose Zn level together with other trace elements could be high and has been reported to range from 443 to 1112 mg/kg (Kabata-Pendias and Mukherjee, 2007). In addition, the elevated concentration of Zinc may be due to anthropogenic activities that are prone to influence its level, especially in the top horizon of soil. A similar study on urban soil contamination conducted in the city of Novokuybyshevsk Russia had a range of 34.75 mg/kg to 73.5 mg/kg (Galitskova and Murzayeva, 2016). A study in the city of Tabriz Iran, revealed a

concentration range of 49.80 mg/kg to 163.80 with a mean of 98.27 mg/kg (Taghipour *et al.*, 2013). A study in Varanashiindia, revealed a concentration range of 86.4 mg/kg to 158.3 mg/kg with a mean concentration of 122.3 mg/kg. (Mishra and Tripathi, 2008). A study in China revealed a concentration range of 31.2 mg/kg to 213.6 mg/kg with a lower mean of 129.9 as compared to the present study (Guo *et al.*, 2013).

Trace elements in sub soil (21-50cm)

Chromium

Chromium concentration of sub soil (21-50 cm) had a concentration mean of 54.67 mg/kg with a range varying from 47 mg/kg to 74 mg/kg (Table 1). From a worldwide basis, Cr mean concentration in urban soil has been reported to be 66.08 mg/kg (Su *et al.*, 2014). A study carried out in Niger Delta; Nigeria reported a mean concentration of Chromium in subsoil to be 23.4 mg/kg with a range of less than 0.002 mg/kg to 34.2 mg/kg (Iwegbue and Iwegbue, 2015). A study in Hangzhou, China revealed a mean concentration of Chromium in sub soil of 43.91 mg/kg with a range of 22 mg/kg to 80.4 mg/kg (Ji *et al.*, 2012).

Manganese

Sub soil (21-50 cm) concentration of Manganese from the study revealed a concentration range that varied from 2864.00 mg/kg to 4627.00 mg/kg with a concentration mean of 3791.38 mg/kg (Table 1). This concentration is low compared to that of topsoil (Table 1). This trend is expected due to fixation of organic matter in topsoils that makes it to accumulate more on top soils (Kabata-pendias and Henryk, 2001). A study carried out in Niger Delta; Nigeria reported a mean concentration of Manganese in subsoil of 169.0 mg/Kg with a range of less than 53.67 mg/kg to 539.4 mg/kg (Iwegbue and Iwegbue, 2015). A similar study carried out in Germany, revealed a mean concentration in sub soil of 821 mg/kg with a range that varied from 433 mg/kg to 4501 mg/kg (Reiss and Chiffard, 2015).

Nickel

Sub soil (21-50 cm) concentration of Nickel had a mean concentration of 30.32 mg/kg with a range that varied from 27.5 mg/kg to 32.50 mg/kg (Table 1). Though the range is within the reported broad

world-wide range of 0.2 mg/kg to 450 mg/kg, the mean of sub soil was higher than the soil world calculated mean of 22 mg/kg (Kabata-pendias and Henryk, 2001). Also, this mean of sub soils was higher compared to the reported world mean of contaminated urban soils which is 29.14 mg/kg (Su *et al.*, 2014). The high Nickel mean content as compared to the world mean can be credited to the parent material as Nickel concentration of soils is extremely reliant on its concentration in background material (Kabata-Pendias, 2011). Nevertheless, higher content of Nickel in soils indicates the added impact of anthropogenic factors and soil-forming processes. A study carried out in Niger Delta; Nigeria reported a mean concentration of Nickel in subsoil to be 26.5 mg/kg with a range of less than 11.9 mg/kg to 37.9 mg/kg (Iwegbue and Iwegbue, 2015). A study in Hangzhou, China revealed a higher mean concentration of Nickel in sub soil of 32.88 mg/kg with a range of 22.1 mg/kg to 58.6 mg/kg (Ji *et al.*, 2012)

Copper

Concentration of Copper in subsoil (21-50 cm) revealed a range of between 9.50mg/kg to 68.50 mg/kg with a concentration mean of 27.83 mg/kg (Table 1). As expected, this concentration mean was lower compared to that of topsoil (0-20 cm) that was 43.90 mg/kg (Table 1). Copper is said to be associated with organic matter (Iwegbue and Iwegbue, 2015), hence, subsoil samples tend to have smaller amounts of Cu in comparison with topsoil samples, perhaps owing to presence of less organic substances in the subsoil and because at the topsoil is where biological activities mainly occur (Abollino *et al.*, 2002). A study carried out in Niger Delta; Nigeria reported a mean concentration of Copper in subsoil to be 5.50 mg/kg with a range of less than 0.002 mg/kg to 15.0 mg/kg (Iwegbue and Iwegbue, 2015). A study in Hangzhou, China revealed a higher mean concentration in sub soil of 37.49 mg/kg with a range of 16.7 mg/kg to 70.9 mg/kg (Ji *et al.*, 2012)

Zinc

From the study, Zinc concentration in sub soil (21-50 cm) revealed a concentration range of between 271.00 mg/kg to 567.50 mg/kg with a concentration mean of 370.32 mg/kg (Table 1). Zinc concentration in soil is said to be subject to organic matter, the type of parent material, texture, and pH, and its world-

wide range is from 10mg/kg to 300 mg/kg with a projected average of 64 mg/kg (Kabata-Pendias, 2001). A study carried out in Niger Delta; Nigeria reported a mean concentration of Zinc in subsoil of 30.8 mg/Kg with a range of less than 8.67 mg/kg to 48.0 mg/kg (Iwegbue and Iwegbue, 2015). A study in Hangzhou, China revealed a mean concentration of Zinc in sub soil of 120.90 mg/kg with a range of 72.5 mg/kg to 215.0 mg/kg (Ji *et al.*, 2012). Like in the top soil (0-20 cm), the mean concentration of Zinc in sub soil (21-50 cm) from the study was high compared to concentrations reported for soils on a world-wide basis (Kabata-pendias and Henryk, 2001) and those from contaminated urban areas (Su *et al.*, 2014). The high Zn content is a distinctive characteristic of contaminated sites whose Zn level may be quite high, from 443 mg/kg to 1112 mg/kg (Kabata-Pendias and Mukherjee, 2007). In addition, anthropogenic source of Zinc may greatly influence its high contents and are most likely responsible for the observed elevated levels of Zn (Kabata-Pendias and Mukherjee, 2007).

Elemental concentration in topsoil compared to sub soil

All the elements; Cr, Mn, Ni, Cu and Zn depicted a higher concentration in the topsoil (0-20 cm) than in the sub soil (21-50 cm) (Table 1) (Fig. 2). The higher concentrations of these elements in topsoil could be due to fixation by soil organic matter (Kabata-Pendias, 2011). These observations is similar to what has been reported by other researches who indicated elemental concentration in soil tends to decrease with depth (Adugna, 2015; Jobbágy and Jackson, 2014). Also, it has been reported that the observed elemental differences between soils horizons is due to the influence of predominating pedogenic and anthropogenic processes (Abbaslou *et al.*, 2014; Kabata-pendias and Henryk, 2001). To establish if the difference of topsoil and sub soil were significant or not, student T-Test were done. Results revealed significant differences ($p \leq 0.05$) for Cr, Cu and Zn whereas for Mn and Ni there were no significant differences ($p \geq 0.05$) (Table 2).

Soil Trace elements concentration during dry and wet seasons

For all the elements investigated (Cr, Mn, Ni, Cu and Zn), their soil mean concentration during dry season was higher than wet season (Table 2) (Fig. 3).

Trace elements in urban farming soils

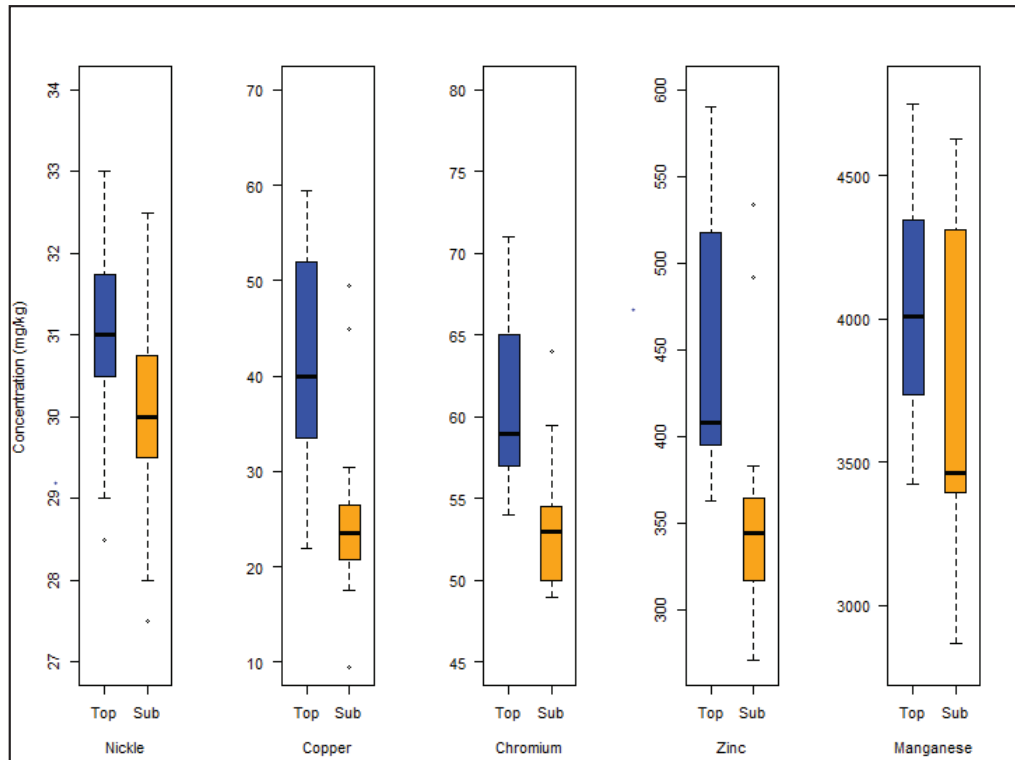


Fig. 2: Box plots of soil elemental concentration of Topsoil and sub soil during Wet season

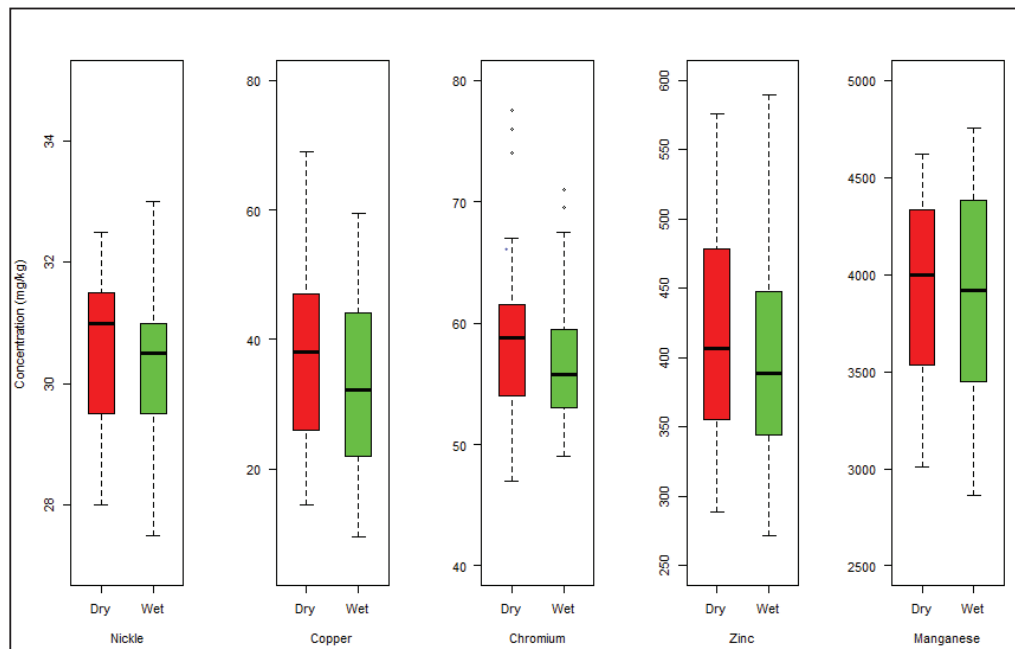


Fig. 3: Box plots of elemental concentration in soil during Dry and wet seasons

Table 2: Basic statistics of elemental concentration in soil during wet and dry season.

Elements Mg/kg	Cr	Mn	Ni	Cu	Zn
Wet season soil Mean	57.07±6.11	3903.02±500.35	30.50±1.41	33.63±13.46	404.42±83.91
Wet season Range	49.00-71.00	2865.00-4752.50	27.50-33.00	9.50-59.50	271.50-590.00
Dry season soil Mean	59.22±7.56	3930.95±503.92	30.63±1.22	38.10±15.64	422.33±85.42
Dry season Range	47.00-59.22	3008.50-4619.00	28.00-32.50	14.50-69.00	289.00-576.00
P - value	.167	.826	.373	.161	.346

Table 3: Correlation coefficient (r) of the trace elements in soil (n = 60)

	Cr	Mn	Cu	Zn	Ni
Cr	1.000				
Mn	0.426	1.000			
Cu	0.920	0.239	1.000		
Zn	0.937	0.262	0.966	1.000	
Ni	0.610	0.286	0.507	0.661	1.000

Statistically, concentration levels of these elements were found to be of no significant difference between the dry season and wet season ($p \geq 0.05$). Other researchers have reported that during wet season trace elements tend to be significantly lower compared to dry season (Osobamiro and Adewuyi, 2015; Teutsch *et al.*, 1999). The differences tend to be as a result of precipitation that has an effect on depletion and enrichment trends of trace elements in soils (Teutsch *et al.*, 1999). Plant uptake, precipitation, discharge and erosion could be responsible for the reduction in trace elements levels in wet season as compared to dry season (Osobamiro and Adewuyi, 2015; Teutsch *et al.*, 1999).

Correlation analysis of the Trace elements concentration in soil

The relationship that exist between elements in the soils is generally due to parent material, effect of pedogenic process and influence of anthropogenic activities (Cheng *et al.*, 2015). Data analysis for the five trace elements (Cr, Mn, Ni, Cu and Zn) showed that there were positive correlations (Table 3) among the five trace elements, implying that the five trace elements in the soils have the same source (Cheng

et al., 2015; Ding *et al.*, 2018). However, Manganese had the least correlation with the rest of the elements an indicator that its major source could be different as compared to the rest of the elements. This is substantiated by the fact that generally most of the soil manganese is from the parent material with minor sources that could be from anthropogenic activities (Hooda, 2010).

CONCLUSION

The urban area is predominantly susceptible to trace elements pollution because of their accumulation in the soil. Nevertheless, urban farming is unceasingly being practiced in major cities including Nairobi and hence adverse effects by these pollutants is inevitable. This notwithstanding, the importance of urban farming cannot be overlooked as it leads to provision of basic foodstuffs to urban residents. It is therefore of essence to have access to accurate, simple and rapid means for their detection in soils to contribute to the understanding of trace elements levels in soil in an urban farming area. The findings of the study revealed that all elements (Cr, Mn, Ni, Cu and Zn) depicted a higher concentration in topsoil than sub soil probably due to fixation by soil organic matter and

influence of pedogenic processes and anthropogenic activities. For all the elements investigated, their soil mean concentration was higher during dry season than wet season. Of the elements investigated, all were above the reported mean on a worldwide basis except for chromium. This indicates that the site is highly contaminated, a fact that was proved by a decrease of elemental concentration between topsoil and subsoil. Nonetheless, the available guidelines seem to be insufficient in assessment of soil contamination for farming as they lack site specific factors like bioavailability of the element, plant type and soil properties that have a great influence on phytotoxicity. These findings recommend a further controlled experiment that could take account of specific factors like bioavailability of trace elements, uptake of various species, presence of other trace elements and soil properties. Such a controlled study would aid in the understanding of bioavailability of trace elements from contaminated soil.

AUTHOR CONTRIBUTIONS

H.O. Nyandika and E. Kitur conceived and designed the experiment. H.O. Nyandika sampled, performed the experiment, analyzed the data, and wrote the paper. J.K. Nzeve revised the draft manuscript. All authors read and approved the final manuscript.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest regarding the publication of this manuscript. In addition, the ethical issues, including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, and redundancy have been completely observed by the authors.

ABBREVIATIONS

% Percentage

$^{\circ}\text{C}$	Degree centigrade
cm	centimeter
Cr	Chromium
Cu	Copper
eV	electron volt
FWHM	Full width height maximum
ICRAF	International center for research in Agroforestry
m	meter
mg/kg	milligram per kilogram
mm	millimeter
Mn	Manganese
Ni	Nickel
PTE	Potentially toxic elements
PXRF	Portable X-ray fluorescence
XRF	X – ray fluorescence
Zn	Zinc
μA	Microampere
μm	micrometer

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ORIGINAL RESEARCH PAPER

Optimization-based planning to assess the level of disaster in the city

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ABSTRACT

BACKGROUND AND OBJECTIVES: After having struck in a major natural disaster like an earthquake, different organizations run about to decrease losses. The lack of accurate demand information is a common problem that all emergency response organizations have to encounter such a crisis. Evaluation of the City disaster level is a mean to feed this information to the disaster response operations. The objective of this research is eschedule a group of experts to assess relief demand. These evaluation teams need to be scheduled to minimize the evaluation time.

METHODS: This paper aims to formulate the routing and scheduling of the assessment teams so that real demand information for savings and rescue would be available as soon as possible. The simulated annealing algorithm is used to solve the scheduling problem.

FINDINGS: Two cost functions, sum of arrival time and max completion time, were evaluated. The latest is found to perform better in evaluation of the teams performance.

CONCLUSION: The performance of the approach is tested on several randomly generated networks and synthesized demand data. The results show a 13 % improvement in the total completion time of operation in comparison with previous approaches.

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INTRODUCTION

A major natural disaster like earthquake kills people around the world every few years. Each emergency management process includes four steps: (i) mitigation, which is all activity that should be done to decrease disaster impact. (ii) Preparedness defined as activities that make society ready for encountering disaster. (iii) The response is also the activities that save the affected people and prepare their primary requirements. (iv) Finally, recovery is the long term scheduled plan that restores damages and builds up the city (Albris *et al.*, 2020; Altay and Green, 2006; Galindo and Batta, 2013). Of course, each of these stages is composed of several operations. Some of these operations are in pre-disaster management and some are in the post (Edrisi and Askari, 2020; Malik and Cruickshank, 2016). One may say the response to disaster is the most critical part of disaster management because it is directly associated with human life and more appropriate performance in this part saves more lives (Konstantinidou *et al.*, 2015; Wu and Chen, 2019). The term appropriate here means fast and accurate, so time is a critical issue. In the emergency response phase, four operations are mostly considered in previous researches: Demand prediction, relief assessment, search and rescue operation, and humanitarian logistics. Relief demand is considered as feed to search and rescue and logistic operations and this may affect the accuracy of operations. However, demand prediction gives the decision-maker a good view, but this data may not be accurate. Prediction of demand is extensively considered in previous researches (Tang *et al.*, 2017). These predictions are mostly taken based on structural and transportation reliability, the strength of buildings, earthquake intensity, and so on (Edrisi and Askari, 2019). This demand data may not be valid as the earthquake is a stochastic process. Of course, different agencies start to collect data immediately after the disaster; For instance, police, regional responders, peoples, hospitals, and so forth. This multi-source data could be useful, but still because of the chaotic and nervous situation right after the disaster, this data also may not be accurate. Urban Relief Assessment Teams (URAT) include prepared and well-trained people that can evaluate damages, assess demand, and estimate humanitarian relief to calculate city disaster level accurately. The objective of these teams is just assessing and sending correct

and real-time information and they never participate in search and rescue operations as time is a sensitive parameter in emergency response. The objective function of these teams is to finish the operation as soon as possible. So pre-routing their vehicles makes this operation more appropriate. This paper presents a formulation to model this problem based on two main problems, Vehicle Routing Problem (VRP) and Parallel Machine Scheduling (PMS) (Bai, 2016; Li and Zhou, 2018; Wex *et al.*, 2014). The contribution of this paper is to utilize these approaches to solve the routing and scheduling of the assessment team. To the best of the authors knowledge, this is the first time that the vehicle routing problem is used for solving the routing and scheduling of the assessment team for the city disaster level. The current study have been carried out in Tehran, Iran in 2019. Among the four mentioned operations of the response phase, relief assessment is less considered in previous studies. However, many other operations require relief assessment as a prior operation. Demand prediction, urban search and rescue operation, and logistics are examples of preliminary operations for relief assessment.

Demand prediction

The challenging point of demand prediction is the uncertain relief demand information in large-scale emergencies (Sarma *et al.*, 2020). Time series and autoregressive models are extensively used to model dynamic demand prediction (Aviv, 2003). Because of diversity in relief demand information sources, Time-varying demand is modeled based on the multi-sensor fusion method (Sheu, 2007). Sun *et al.*, (2013) proposed a fuzzy rough set approach for emergency demand prediction to overcome inaccuracy and incomplete information and also the chaotic environment of decision making.

Urban search and rescue operation

Minimizing the number of fatalities is the main aim of search and rescue operations (Nadi and Edrisi, 2017). The findings proof that the cooperation between assessment and response teams can improve the total life saving in an emergency response. Fiedrich *et al.*, (2000) Modeled a dynamic optimization approach to locating resources respect to minimization of fatalities in this operation. This is almost the case with robot-focused search and

rescue operations and decision support systems. Blitch (1996) Demonstrated the critical issue in the application of knowledge-based artificial intelligence and robotics to the urban search and rescue (USAR) operation. Chen and Miller-Hooks (2012) Proposed multistage stochastic programming based on the column generation method to route USAR teams. Their objective was the maximization of the total number of survived people in this operation.

Logistic operations

The disaster relief logistic operation is well considered in previous researches (Rodriguez-Espindola *et al.*, 2018). Luis *et al.*, (2012) Represented a comprehensive review of routing problems that have been solved to deliver goods and services to disaster-affected regions. In logistic operation, different objective functions have been taken introduced and evaluated. They identified several areas where modeling can capture more characteristics of relief distribution. Besides, they have found that Risk-averse behavior in routing has not been studied in depth yet while the characteristics of different disasters and relief organizations will continue to provide more opportunities and challenges for researchers. Barbarosoğlu and Arda (2004) Used the total cost of deliveries respect to satisfying all demands, and Ozdamar *et al.*, (2004) proposed an integrated multi-commodity network and vehicle routing problem to model mixed pick-up and delivery planes. Their findings indicate that the method discloses the uncertainty during the progress of the response. Yi and Kumar (2007) Proposed an ant colony optimization to minimize the sum of unsatisfied demand for all commodities and also unsaved people in each node. All the above-mentioned operations are preliminary to the urban relief assessment operation which is the main subject of this study.

Urban relief assessment operation

While emergency response is well studied in other phases, but there are just a few studies that consider optimization in urban relief assessment operations (Zhu *et al.*, 2020). Huang *et al.*, (2013) Introduced an assessment routing problem and proposed a continuous approximation approach to solving it. They compare discrete optimization with their purposed continuous algorithm; however, their approach reduces the need for detailed data.

Nevertheless, they use the sum of arrival time as the objective function. In the case of the assessment team, as time is susceptible, this objective function could not be the perfect one. However, the sum of arrival time can consider the service time of each region (Campbell *et al.*, 2008), but the service time of the last region in the list of each vehicle would not be considered. In this paper, a discrete simulated annealing optimization used to find the best route for URAT considering parallel machine scheduling and vehicle routing problems.

MATERIALS AND METHODS

To formulate the proposed model as an optimization problem, following introduces the used notation in this approach.

Notations

K	number of vehicles in the depot
I	number of affected regions
$S_{i,k}$	Service time of region i for vehicle k
$ST_{i,k}$	The start time of vehicle k in region i
$FT_{i,k}$	Finish time of vehicle k in region i
P_i	The population of region i
R_i	Vulnerability ratio of region i
D_i	Relief demand of region i
$To_{i,k}$	Travel time of vehicle k between depot and region i
$T_{i,j,k}$	Travel time of vehicle k between region i and j
$A_{i,k}$	Arrival time of vehicle k to region i
V_i	Speed of vehicle k
C_k	Completion time of vehicle k
$Cmax_k$	Maximum completion time
A_k	Sum of arrival time for vehicle k
$X_{i,j,k}$	Flow variable that is equal to 1 if (i,j) is traversed by vehicle k and 0 otherwise
$Xo_{j,k}$	Flow variable that is equal to 1 if the link from depot and j is traversed by vehicle k and 0 otherwise
T	control parameter of the SA algorithm

Problem configuration

This study considers a hypothetical city that is divided into n affected area. These regions are assumed to be clustered into the I regions based on the vulnerability ratio in the demand prediction phase. Vulnerability ratio is a measure to define the level of vulnerability of a zone to damages in natural disasters.

This nominal vulnerability ratio is not exact and the main aim of urban assessment teams is to

evaluate the right vulnerability ratio, but this nominal ratio can be used as the initial feed of URAT. Each region i has an entire population P_i that is randomly generated to model this problem. Vulnerability ratio R_i of region i is a random variable between 0 and 1. Relief demand of each region is $D_i = R_i \times P_i$ (Edrissi *et al.*, 2013). For each vehicle k in region i there is a service time $S_{i,k}$ that is generated proportionately to D_i . This means in region i service time is different for each vehicle, because in reality, different teams have different functionality, efficiency, and performance. V_k is a randomly generated variable for each vehicle k , so travel time can be calculated respect to distances. Also, in Fig. 1, each region has a start, service, and finish time that starts and finish time can be calculated with Eq. 1 and Eq. 2.

$$ST_{j,k} = FT_{i,k} + T_{ij,k} \quad (1)$$

$$FT_{i,k} = ST_{i,k} + S_{i,k} \quad (2)$$

Based on the above configuration, this vehicle routing problem is modeled as parallel machine scheduling. PMS and VRP are mathematically adequate. In PMS, each machine has to process a set of works. Here works are the regions. Each work has process time that is proportionate to service time and each work has a setup time that can be considered as travel time in this problem.

Problem formulation

As vehicles in this problem do not need to carry any equipment, URAT is an incapacitated vehicle routing problem. It is mentioned that their mission is just to evaluate the vulnerability ratio and they do not have to perform any Logistic or search and

rescue operations. This problem also does not need any time windows constraint. Because this operation starts right after the disaster and all regions should be visited as soon as possible. In this paper, the objective function of this problem shown in eq.4 is considered to the minimum, maximum completion time of vehicles. The completion time C_k of each vehicle is the finish time of the last region in the list of vehicle k . The maximum completion time is calculated with Eq. 3, and the problem tries to minimize that in Eq. 4.

$$C_{\max_k} = \max_{k \in K} \sum C_k \quad (3)$$

This problem is formulated as follows:

$$\min \sum_{k \in K} C_{\max_k} \quad (4)$$

Subject to:

$$\sum_{j \in I} \sum_{k \in K} X_{i,j,k} = 1 \quad (\forall i) \quad (5)$$

$$\sum_{j \in I} \sum_{k \in K} X_{0,j,k} \leq K \quad (6)$$

$$\sum_{j \in I} X_{i,j,k} - \sum_{j \in I} X_{j,i,k} = 0 \quad (\forall i) \quad (7)$$

$$\sum_{j \in I} X_{0,j,k} = 1 \quad (\forall k) \quad (8)$$

$$FT_{i,k} + T_{i,j,k} \leq FT_{i,k} + M(1 - X_{i,j,k}) \quad (\forall i, j) \quad (9)$$

$$FT_{i,k} \geq (T_{0,i,k} X_{0,i,k}) \quad (\forall i, k) \quad (10)$$

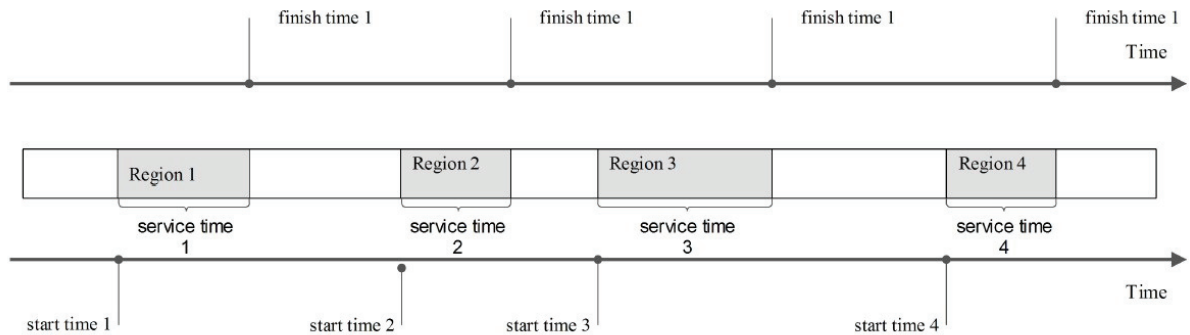


Fig. 1: Time Horizon of each vehicle

$$X_{ij} \in \{0,1\} \quad (\forall i, j) \quad (11)$$

$$FT_{i,k} \geq 0, \quad T_{i,j,k} \geq 0 \quad (\forall i) \quad (12)$$

Eq. 5 ensures that all nodes are visited. Eq. 6 indicates that k vehicle is used for this operation. Eq. 7 makes sure that each node is visited once. Eq. 8 makes sure that the number of vehicles dispatched is limited to the maximum number of available vehicles. Finally, sub tours are eliminated by the well-known big M method in Eqs. 9 to 11, and Eq. 12 ensures the non-negativity of the finish and travel time, respectively. Fig. 2 shows the procedure of solving this model using simulated annealing. Simulated Annealing (SA) Metaheuristic is used to optimize the objective function of this problem. SA is a stochastic memoryless algorithm. This means that it does not gather any information during the search. This algorithm aims to delay the convergence and escape from local optima (Gonzalez-R *et al.*, 2020).

This algorithm is an iterative process. At each iteration, a randomly generated neighbor changes with operators. This new neighbor is acceptable if the cost function $f(x')$ of this solution is higher than the previous. Otherwise, this solution is accepted with special probability. This probability depends on the cost difference of these two solutions and the current temperature or control parameter. This temperature is reducing slowly in the next iteration. So the acceptance chance of such a solution decreases. Generally, this probability follows the Boltzmann distribution, which is shown in Eq.13.

$$P(\Delta f, T) = e^{-\frac{f(x') - f(s)}{T}} \quad (13)$$

The novelties of this research are :

1. Formulating routing and scheduling of assessment teams for disaster level in a city.
2. the performance factor of vehicles is added to the formulation to make this problem close to the real situation.
3. max completion time is used instead of the sum of arrival time as a cost function because the performance factor of vehicles can reflect on this objective more accurately.
4. SA algorithm is utilized to solve this optimization problem in an iterative approach.

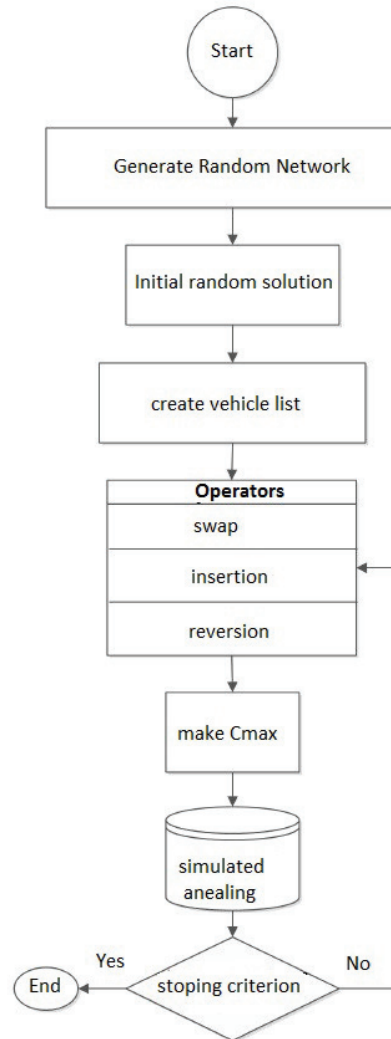


Fig. 2: PMS procedure of vehicle routing URAT

RESULTS AND DISCUSSION

This model is solved in 6 randomly generated networks. The total number of nodes ranges from 5 to 40. The number of vehicles is ranged from 2 to 5 vehicles proportionally. Despite economic problems, in disaster management, depot location should be allocated outside of affected regions. One depot is randomly allocated for each network in this model. The demand of each node is ranged from 10 to 100. The service time of nodes is generated for each vehicle. As mentioned in the previous section, the service time is proportionate to population. it is

Table 1: Properties of randomly generated network

Network	No. of nodes	No. of vehicles
1	5	2
2	10	3
3	15	3
4	20	4
5	30	5
6	40	5

assumed that for one population unit, from 0.1 to 0.5-time unit (for example, minute) is assumed for each vehicle to assess vulnerability. This 0.1 to 0.5 random variable is called Performance Factor (PF). The speed of each vehicle is randomly generated as an integer number between range [10-20] kilometer per hour. This speed is used to calculate travel times in the network. Table 1 indicates the properties of the network.

This problem is solved for each network twice, once concerning maximum completion time as the objective function and once with arrival time. Several iterations for both of these objective functions in each network is constant. Table 2 shows the results for each network. Table 2 compares the results with previous researches indicating that using Cmax instead of the sum of arrival time causes the urban relief assessment team's process to complete sooner. This improvement is averagely 13 percent. The reason for the improvement is that in the sum of arrival time, the performance factor of vehicles does not make

sense. While Because of the stochastic situation of emergency response, the performance factor of each vehicle is not constant. That is maybe vehicle k arrives in region i sooner than vehicle k', but because of the low-performance factor of vehicle k, the vehicle k' can finish assessing this region sooner. Assuming that the PF of each vehicle is constant, still, the processing time of the last region in the list of each vehicle is not considered. This fact is shown in the solution column of Table 2. The purposed model in this paper is programmed using Matlab R2012a on a Core i7 and 2 gigahertz Asus with 4 GB RAM.

Fig. 3 depicts the procedure of optimization. It shows that for a specific number of iteration, the best cost of scheduling becomes unchanged for a while and this is the stopping criteria of optimization. Fig 3 is a means to validate the result from the optimization process. It shows that the model is converted to an optimum solution and the algorithm had enough time to explore the search space!

In case of a route closure, the cost of that link is high and consequently, the algorithm finds an alternative solution with the lowest cost. This model can be utilized to be used in a megacity like Tehran. Tehran has 22 municipalities which can be interpreted as 22 nodes. Since this model can quickly converge for networks as big as with 40 nodes. It can easily be adapted for a case study in Tehran. The limitation of this model is that it requires vulnerability ratio of each municipality region. This vulnerably ratio should be evaluated before a disaster.

Table 2: results of model and comparison between Cmax and Arrival time

Net.	Objective function	completion time (minutes)	Improvement (percent)	Solution (Rout)
1	Cmax	99	8	1-5/2-3-4
1	A	107	-	1-3/2-5-4
2	Cmax	129	23	5-6/7-4-1-10-8/9-3-2
2	A	159	-	5-6-2/7-4-1-10-8/9-3
3	Cmax	93	22	6-10-12-2/14-11-9-4-8/13-15-1-5-7-3
3	A	114	-	6-10-12-2/14-11-9-4-7/13-15-1-5-8-3
4	Cmax	177	6	3-6-18-14-8/13-1-7-17-16/15-19-12-10-2/11-20-5-4-9
4	A	188	-	3-6-18-14-8/13-1-7-17-2/15-19-12-10/11-20-5-4-9-16
5	Cmax	114	22	25-3-22-7-4-19-14-21/1-28-23-16-24-6/9-6-18-29-20-10/27-17-26-15-11/8-5-12-13-30
5	A	140	-	25-3-22-7-4-19-14/1-28-23-16-24-21/9-6-18-29-20-10/27-17-26-15-11/8-5-12-13-30-24
6	Cmax	202	8	37-13-1-3-7-29-11-38/2-32-33-18-15-35-31-12/22-25-9-6-26-10/34-21-23-36-5-27-8-40-19/20-24-16-39-17-14-28-4-30
6	A	219	-	37-13-1-3-7-29-11-38/2-32-33-18-15-35-31-12/22-25-9-6-26-10-19/34-21-23-36-5-27-8-40/20-24-16-39-17-14-28-4-30

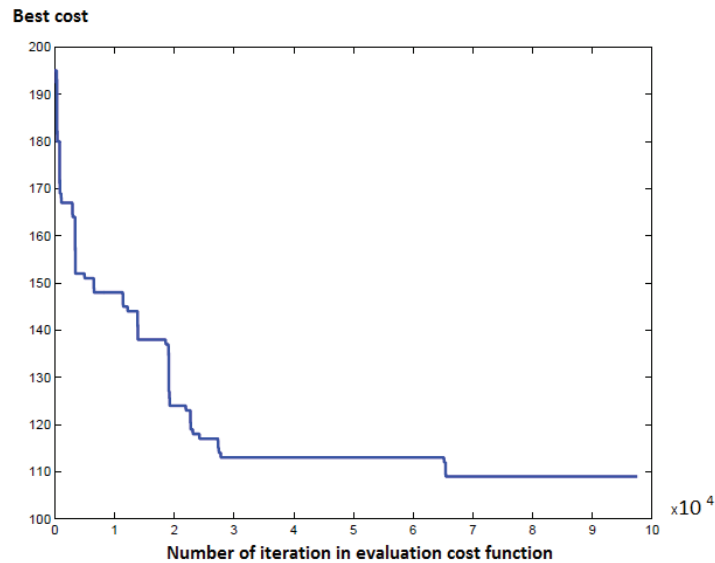


Fig. 3: Number of iteration for the sum of arrival time

CONCLUSION

One crucial part of emergency response operation is accurate relief demand information; this data mostly gathered by people how are not an expert. While sending urban relief assessment teams can give correct and accurate information. As this operation is time-sensitive, a vehicle routing and parallel machine scheduling approach are proposed in this paper. Performance factor (PF) is defined for each vehicle to model this problem more realistic. This performance factor depends on different features, for example, the experience, characteristics, and age of this team's member. In this case, the previously used objective function, sum of arrival time, is not appropriate. So a maximum completion time is used instead and this led to a 13 % improvement of total URAT process on average. For future research, solving this problem with continuous approximation reduces the need for detailed data so it can improve the results. Integrating these teams with the search and rescue team also can lead to better performance in emergency response. Evaluation of PF is an important part that needs more studies. Finally, the application to a practical use case for which the data are known would add to the present study the benefits that this modeling could bring in practice.

AUTHOR CONTRIBUTIONS

A. Nadi commenced the process by concept-

ualizing and formulating the research idea and also interpreting the results. M. Askari reviewed the literature and prepared the manuscript. A. Edrisi reviewed and edited the final manuscript.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest regarding the publication of this manuscript. In addition, the ethical issues, including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, and redundancy have been completely observed by the authors.

ABBREVIATIONS

URAR	Urban Relief Assessment Teams
VRP	Vehicle Routing Problem
PMS	Parallel Machine Scheduling
USAR	Urban Search And Rescue
SA	Simulated Annealing
PF	Performance Factor

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ORIGINAL RESEARCH PAPER

The impact of coronavirus induced general holiday on air quality in urban area

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ABSTRACT

BACKGROUND AND OBJECTIVES: The Bangladesh government declared a general holiday beginning on March 26, 2020 aimed to combat coronavirus (COVID-19) pandemic. The aim of this study was to assess the impacts of the general holiday on air quality in Dhaka city area of Bangladesh.

METHODS: Hourly $PM_{2.5}$ (aerodynamic diameter $\leq 2.5 \mu m$) data was collected from publicly available World's Air Pollution: Real-time Air Quality Index Project from March 1 to May 16 for the five years 2016 to 2020. Tukey Multiple Comparison test was conducted to address the observable level of air quality changes between the years. Additionally, Moderate Resolution Imaging Spectroradiometer using the Aerosol Optical Depth with 550_{nm} wavelength was analyzed during the same time period.

FINDINGS: This Study found that, between April 7 and May 16, the mean daily reading of $PM_{2.5}$ was less in 2020 when compared to previous years. The mean hourly reported $PM_{2.5}$ during working hours of 6AM and 8 PM for 2020 was statistically lower (at $\alpha = 0.01$ level) than all other years 2019, 2018, 2017 and 2016. The mean hourly reported $PM_{2.5}$ for 2019 was statistically higher (at $\alpha = 0.01$ level) than all other years 2020, 2018, 2017, and 2016. The Bus Rapid Transit and Mass Rapid Transit Construction in 2019 contributed between 24.2% and 38.6% of the $PM_{2.5}$ dust during this period. The elimination of diesel bus traffic during working hours in 2020 reduced the dust levels between 15.9% and 36.3% compared to the previous four years. A declining trend of AOD550 values was observed from April 7 to May 16, 2020 compared to previous four years (2016-2019).

CONCLUSION: During the general holiday period in Dhaka, the daily and working hour $PM_{2.5}$ as well as daily Aerosol Optical Depth were reduced compared to previous four years (2016-2019). Government action is recommended to reduce dust created during major construction projects. It is recommended the government authorize the replacement of buses with less polluting vehicles.

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INTRODUCTION

A previously unknown coronavirus disease (COVID-19) was first introduced in Wuhan City, China in December 2019 and was capable of infecting the human's body (Cui *et al.*, 2019; Lu *et al.*, 2020). World Health Organization (WHO) declared the COVID-19 outbreak a public health emergency of international concern on 30 January 2020 (WHO, 2020). Around the world the COVID-19 pandemic has brought devastating consequences (Wang *et al.*, 2020). Due to the COVID-19 outbreak the global economy could suffer from \$5.8 to \$8.8 trillion loss, equivalent to 6.4% to 9.7% of global gross domestic product (GDP) (ADB, 2020). In addition, more than 25 million people could be unemployed by the end of 2020 depending on how quickly the economy recovers in the second half of the year (ILO, 2020). The first three confirmed cases of COVID-19 in Bangladesh were identified on March 8, 2020 by the country's epidemiology institute, Institute of Epidemiology Disease Control and Research (IEDCR). According to IEDCR report, the case number remained low until the end of March but subsequently the number of infections in the country has grown significantly. As of June 4, 2020, there have been a total of 57,563 confirmed cases in Bangladesh, with 12,161 recoveries and 781 deaths (IEDCR, 2020). To avoid the COVID-19 spread, the government of Bangladesh closed all education institutions since March 17, 2020. On March 26, 2020 the government declared a nationwide general holiday to combat COVID-19 outbreak. During this holiday all non-essential businesses were shuttered. This included the brick kilns, cement factories, garment factories, other small factories and office buildings. As a result the amount of emissions in the air from factories and businesses was reduced. Most construction was halted including the large Bus Rapid Transit (BRT) and Mass Rapid Transit (MRT) projects. Buses were not allowed to operate during this holiday period (Razib *et al.*, 2020). Only private automobiles, Compressed Natural Gas (CNG) vehicles, and rickshaws were permitted during daytime hours. Trucks delivering essential goods were not allowed to travel in the city during working hours, 6AM to 8 PM. Despite the severe negative impacts of COVID-19 on human health and economy, it has had positive results in air pollution reduction due to limited social and economic activities (Dutheil *et al.*, 2020). Dhaka was

ranked the world's second most polluted city after Delhi in 2019 for $PM_{2.5}$ exposure (IQAir, 2019). In the city of Dhaka there appear to be many sources contributing to the airborne fine particular matter (referred to as $PM_{2.5}$ since the particles measured are less than 2.5 microns in diameter). Previous studies have identified brick kilns located near Dhaka, particularly to the north and west of the city, as significant contributors (Nayeem *et al.*, 2019; Rana *et al.*, 2016). Uncontrolled open burning of trash occurs in many areas of the city. Vehicle exhaust has been identified as a significant source, particularly from diesel operated buses and heavy trucks (Rana *et al.*, 2020). Heavy trucks have been restricted from traveling in downtown Dhaka during daylight hours (6 AM until 8 PM) (Begum *et al.*, 2011). During these working hours, buses facilitate the commuting of workers to workplaces and students to school. More recently, additional dust has been created with the construction of the new mass transportation systems Bus Rapid Transit (BRT) and Mass Rapid Transit (MRT) (Hossain *et al.*, 2019). Overriding these sources resulting from human activities is the variation in weather conditions (Kayes *et al.*, 2019). While storm fronts may temporarily clear the air and bring in fresh non-polluted conditions, a stationary front or lack of wind for any length of time increases pollution resulting in higher measured levels of $PM_{2.5}$ and other air contaminants (Rana *et al.*, 2016; Begum *et al.*, 2011). These weather conditions may lead to reported levels of $PM_{2.5}$ of very high variability (Majumder *et al.*, 2020). Air Quality Index (AQI) standards have been established by United States Environmental Protection Agency (USEPA) to describe how polluted the air currently is or it is forecast to become (USEPA, 2012). The internationally accepted AQI standards are presented in Table 1. Due to lockdown to combat the coronavirus outbreak with vehicles off the road and industries shut, the presence of major air pollutants have reduced significantly in several countries and territories (Singh and Chakraborty, 2020; Shrestha *et al.*, 2020; Nadzir *et al.*, 2020). Recent satellite based scientific studies conducted in a number of countries and cities (Nakada and Urban, 2020; Tobías *et al.*, 2020; He *et al.*, 2020) show air pollution reduction rate during this pandemic period. Approximately 20-30% reduction of particulate matter ($PM_{2.5}$) in China in February 2020 was reported when compared to

Table 1. Internationally Accepted Air Quality Index (AQI) Standard for $PM_{2.5}$

$PM_{2.5}$ $\mu g/m^3$ (24hour)	Air Quality Index (AQI) Values	Levels of Health Concern	Colors
0.0-12.5	0 to 50	Good	Green
12.1-35.4	51 to 100	Moderate	Yellow
35.5-55.4	101 to 150	Unhealthy for Sensitive Groups	Orange
55.5-150.4	151 to 200	Unhealthy	Red
150.5-250.4	201 to 300	Very Unhealthy	Purple
250.5-500+	301 to 500	Hazardous	Maroon

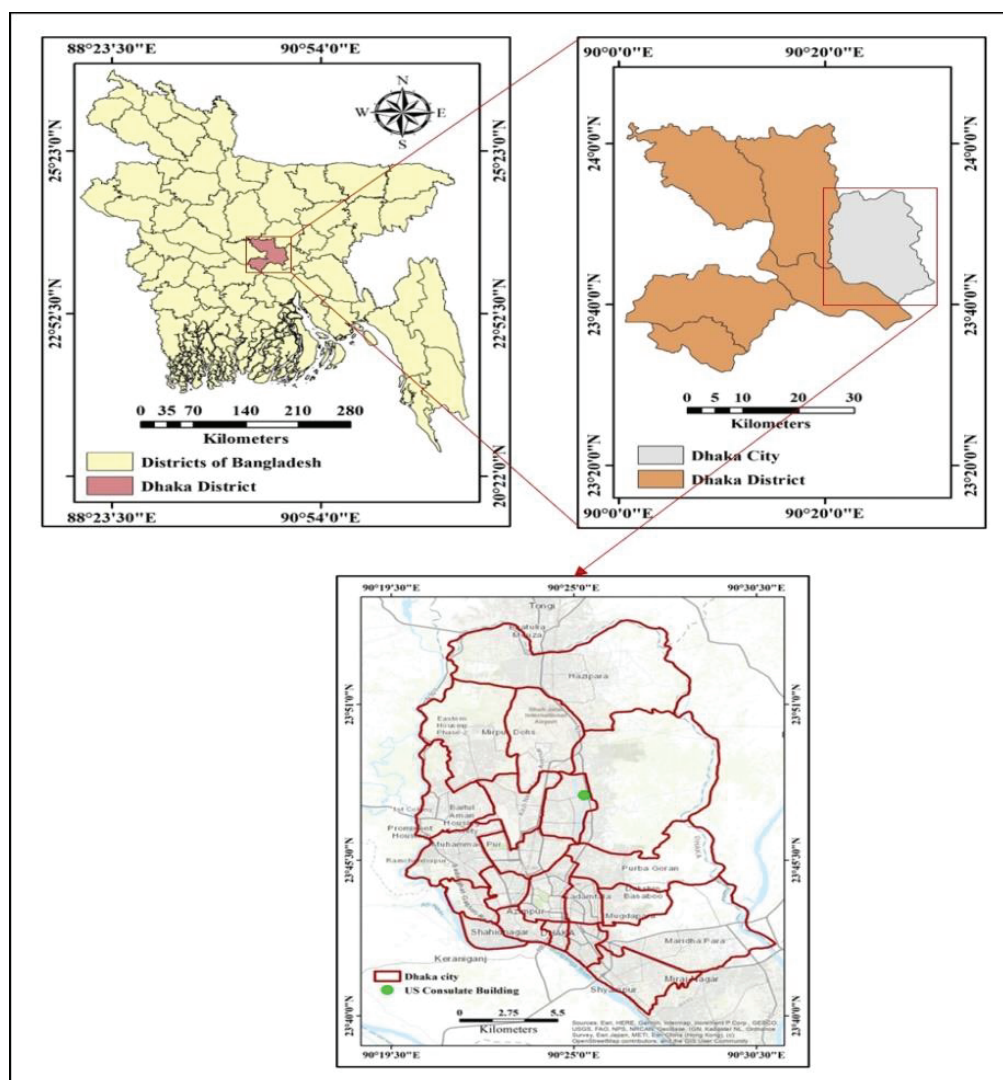


Fig. 1: Geographic Location of the Study Area Showing Dhaka City in Bangladesh

monthly averages of February 2017, 2018 and 2019 (Zambrano-Monserate *et al.*, 2020). In India, there is a reported 43% and 31% reduction of $PM_{2.5}$ and PM_{10} respectively, during the lockdown compared to

the same time period of the past four years (Sharma *et al.*, 2020). In Chittagong city, Bangladesh $PM_{2.5}$ is reduced almost 40% during the COVID-19 shutdown compare to previous 8 years (Masum and Pal, 2020).

This paper analyzes the variations of ground based $PM_{2.5}$ and satellite derived Aerosol Optical Depth (AOD) in Greater Dhaka Region, Bangladesh during the five years (2016–2020) at the same time span of March 1 to May 16. Comparison of data in the five years helps in understanding the potential Impact of the General Holiday declared by the government during this COVID-19 outbreak. Policymakers may get recommendations from this study to combat future air pollution in Bangladesh.

MATERIALS AND METHODS

$PM_{2.5}$ Data Collection and Analysis

Hourly $PM_{2.5}$ with real-time Air Quality Index (AQI) data were retrieved from publicly available air quality data provided by the World's Air Pollution: Real-time Air Quality Index Project. In Bangladesh the ground based monitoring station is located at the United States (US) Embassy in Dhaka, on a building located at $23^{\circ}47'4.93''N$, $90^{\circ}25'19.09''E$ approximately 10 m above ground level to minimize highly concentrated local sources of PM from mechanically generated dust, and immediate local traffic and construction (Fig. 1). This monitoring site is close to the heavily trafficked Bir Uttam Rafiqul Islam Avenue and Madani Avenue. To investigate the effect of COVID-19 pandemic, data from March 1 to May 16 for the last five years (2016–2020) was analyzed. While data from a single

monitoring station cannot be applied to an entire city, however, this analysis provides some indication of the relative impact on $PM_{2.5}$ resulting from the general holiday shutdown. SPSSv20 and Microsoft Excelv10 were used for data processing, analysis and to prepare necessary tables and graphs. Using Tukey Multiple Comparison, testing was conducted to address the level of changes between the years.

Moderate Resolution Imaging Spectroradiometer (MODIS) Product

The daily AOD study data was obtained from MODIS instrumentation on board the Terra and Aqua satellites. Level 3 data was downloaded from National Aeronautics and Space Administration (NASA) GIOVANNI website. MODIS Level 3 data are quality checked and globally gridded over $1^{\circ} \times 1^{\circ}$ grid resolution (Levy *et al.*, 2019). Deep Blue (DB) algorithm at 550_{nm} wavelength over the box shape corresponding to region: $90.33E$, $23.67N$, $90.53E$, $23.9N$ was used in this study (Hsu *et al.*, 2012). These coordinates encompass the Dhaka mega city area. AOD data were collected from March 1 to May 16 in 2016–2020 respectively. The AOD data have discontinuities in some of the days. Daily mean AOD values were used in this study to identify the influence of COVID-19 pandemic on atmospheric aerosols over Dhaka city.

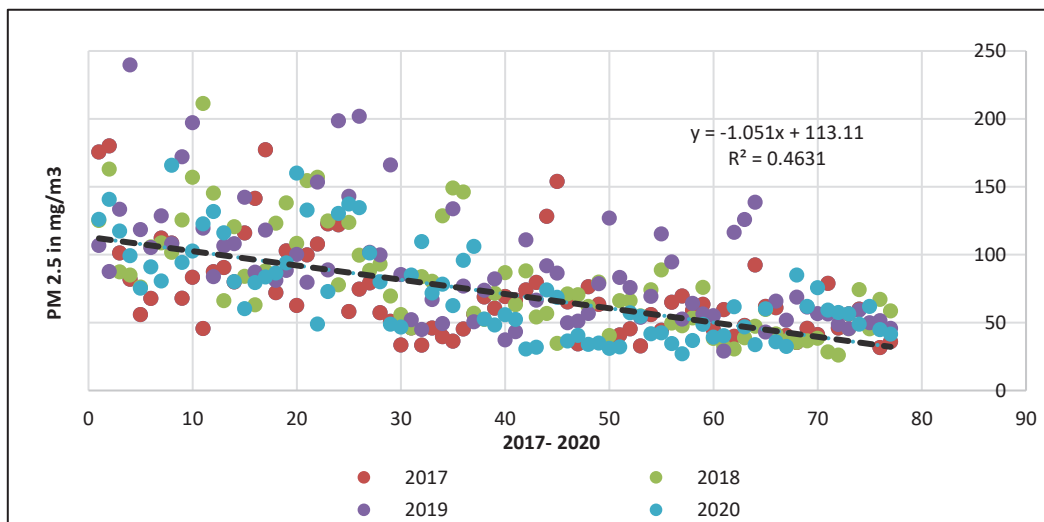


Fig. 2: Scattered Plot of Daily mean $PM_{2.5}$ ($\mu g/m^3$) in Dhaka during 2017–2020 (March 1 to May 16)

RESULT AND DISCUSSION

Variation of $PM_{2.5}$

The $PM_{2.5}$ daily average data collected from March 1 to May 16 for the years 2016 to 2020 was plotted and analyzed using a linear regression (Fig. 2). From the plot it is evident that the daily average values vary from $26 \mu\text{g}/\text{m}^3$ to $236 \mu\text{g}/\text{m}^3$ an almost 10 fold range. Inspection of the hourly values showed an even wider range from $5 \mu\text{g}/\text{m}^3$ to $500 \mu\text{g}/\text{m}^3$. This data reflects a considerable variation from day to day. The plot shows higher values before the 30th day (April 1). After April 1 most brick kilns cease operation each year. Besides, it is also shows that the 2020 air pollution ($PM_{2.5}$) is lower than the previous three years.

The mean daily values for the time periods of March 1 to May 16 (77 days) and April 7 to May 16 (40 days) are shown in Table 2. This table shows that the average $PM_{2.5}$ for the 77 day period of each year exceeded the $55.4 \mu\text{g}/\text{m}^3$ set for the maximum level described as “Unhealthy for Sensitive Groups”. Only in 2017 and 2019 were the mean values higher during the 40 day period after most brick kilns were shut down. In 2020 during the shutdown and business

restriction due to the coronavirus (April 7 and after) was the average $PM_{2.5}$ in the mid-range of “Unhealthy for Sensitive Groups” category. The daily $PM_{2.5}$ was 31.7 % less during COVID-19 outbreak in Dhaka when compared to 2019 period. It was 36.3% less if compared with working hour concentration (6 AM-8 PM). The concentration was also less in 2020 when compared with 2016, 2017 and 2018.

Table 3 shows the hourly US Air Quality Index (AQI) for the days from April 7 through May 16 (40 days) for the years 2016-2020. In 2017, 2018, 2019 and 2020 data points were missing for 5, 95, 68 and 5 respectively out of possible 960 data points. This investigation found a few “Good Air Quality” hours only in 2018 and 2020. The number of “Moderate Air Quality” hour was higher in 2020 for the 40 day April 7 to May 16 period when compared to previous years at the same time, and there were fewer days of “Unhealthy for Sensitive Groups”, “Unhealthy”, and “Very Unhealthy” as defined in the AQI Categories than the previous four years. There were 4 “Hazardous” air quality hours reported in 2017 and 11 in 2019; there were no “Hazardous” air quality

Table 2: Daily mean of $PM_{2.5}$ ($\mu\text{g}/\text{m}^3$) with relative changes (%) during 2016-2020 in Dhaka mega city

Year	Daily Mean of $PM_{2.5}$					Relative Changes (%)			
	2016	2017	2018	2019	2020	A	B	C	D
March 1- May 16 (77 days) (24 hours)	75.4	57.2	64.3	76.6	57.8	-23.3	+1.0	-10.1	-24.5
April 7- May 16 (40 days) (24 hours)	52.4	59.4	54.6	69.7	47.6	-9.2	-19.9	-12.8	-31.7
April 7- May 16 during 6AM -8 PM (15hours)	53.3	57.0	50.9	70.3	44.8	-15.9	-21.4	-12.0	-36.3

Note: A= 2020 vs 2016; B = 2020 vs 2017; C= 2020 vs 2018; D=2020 vs 2019

Table 3: Number of Hour of US AQI Category in Dhaka from April 7 to May 16 (2016-2020)

AQI Category	2016	2017	2018	2019	2020
Good (0-50)	-	-	9	-	5
Moderate (51-100)	129	170	234	114	357
Unhealthy for Sensitive Groups (101-150)	284	411	308	403	291
Unhealthy (151-200)	546	352	313	331	301
Very Unhealthy (201-300)	1	22	10	44	6
Hazardous (301+)	-	4	-	11	-
Total Hour	960	955	865	892	955

Table 4. Daily Average Statistical Comparison of $PM_{2.5}$ during April 7- May 16

Year	2019	2018	2017
2020	Lower at $\alpha = 0.05$	Not Significantly Different	Lower at $\alpha = 0.10$
2019		Higher at the $\alpha = 0.05$	Higher at the $\alpha = 0.20$
2018	Lower at $\alpha = 0.05$		Not Significantly different
2017	Lower at $\alpha = 0.20$	Not Significantly different	

hours reported in 2016, 2018 and 2020.

To test whether the 2020 data from the time of the General Holiday (April 7 until May 16) was significantly lower, a Tukey Multiple Comparison test with equal sample size of the daily $PM_{2.5}$ data was conducted. Initially the daily average values were compared and analyzed (Table 4). The 2020 daily average was significantly lower than the 2019 daily average at the 0.05 confidence level but was only significantly lower than the 2017 daily average at the 0.10 confidence level. The 2020 daily average was not significantly lower than the 2018 daily average. The 2019 daily average was higher than the 2018 daily average at the 0.05 confidence level and higher than the 2017 daily average at the 0.20 confidence level. The mean daily data showed trends but less than convincing statistical differences.

Further examination evaluated the reported hourly data for working hours from 6AM to 8 PM (15 hours) for the 40 days from April 7 through May 16 for the years 2016, 2017, 2018, 2019, and 2020 using the Tukey Multiple Comparison test. It should be noted that in 2018 data points were missing for 68 out of a possible 600 data points. In 2019 data points were missing for 31 out of 600 possible data points. It appears there were some equipment problems during these years. To allow for calculations, the average of the remaining data for each of those years was added to the respective data sets so that each of the five years had 600 data points. The results of these calculations provided more convincing results as reflected in Table 5. The hourly reported $PM_{2.5}$ for 2020 was statistically lower (at $\alpha = 0.01$ confidence level) than all other years 2019, 2018, 2017, 2016. The hourly reported $PM_{2.5}$ for 2019 was statistically higher (at $\alpha = 0.01$ level) than all other years 2020, 2018, 2017, and 2016. The 2018 hourly reported $PM_{2.5}$ was statistically lower than the 2017 hourly data (at $\alpha = 0.01$ level) but not the 2016 hourly data. There was no statistical difference between the hourly

reported data for 2017 and 2016.

Fig. 2 shows that there is a great deal of scatter in the daily $PM_{2.5}$ data reported from the AQI station at the US Embassy in Dhaka. What is not obvious is the relative importance of various cofactors that contribute to the $PM_{2.5}$. Weather conditions contribute to the day to day (and even hour to hour) scatter of the data. This study investigated the effect of human activities that contribute to the $PM_{2.5}$ levels. The inspection of all data collected each year from March 1 to May 16 (77 days) showed that the highest daily reading reported in each year was $180 \mu\text{g}/\text{m}^3$ in 2017; $211 \mu\text{g}/\text{m}^3$ in 2018; $240 \mu\text{g}/\text{m}^3$ in 2019; and $166 \mu\text{g}/\text{m}^3$ in 2020. These highest levels occurred in all years during March when several factors simultaneously contribute to the $PM_{2.5}$ air pollution. These include emission from brick kilns, combustion products from unauthorized open burning, dust generated from construction, emission from diesel trucks (that operate in central Dhaka at night only), diesel emission from buses, and emission from autos and CNG vehicles. Clearly all of these daily maximum values exceed the “Very Unhealthy” level of $150 \mu\text{g}/\text{m}^3$ for 24 hours and represent a significant risk to people living and working in Dhaka. In an attempt to determine the impact of each of these emission sources this study stratified the data to eliminate factors as contributing sources. In the 40 day time period between April 7 and May 16 the highest daily reading was $90.5 \mu\text{g}/\text{m}^3$ in 2016; $153.9 \mu\text{g}/\text{m}^3$ in 2017; $88.7 \mu\text{g}/\text{m}^3$ in 2018; $138.5 \mu\text{g}/\text{m}^3$ in 2019; and $84.9 \mu\text{g}/\text{m}^3$ in 2020. This period is after most brick kilns have shut down for the season. Only in 2017 was there a daily value that exceeded the $150.5 \mu\text{g}/\text{m}^3$, “Very Unhealthy” AQI standard. In 2016, 2018, 2019, 2020 the highest daily value reached the “Unhealthy” range (55.4 – $150.4 \mu\text{g}/\text{m}^3$). As shown in Table 2 the mean values were lower after most brick kilns were shut down for the season for 2018, 2019, and 2020. In 2017 the mean daily value was

Table 5. Statistical Comparison between Working Hourly $PM_{2.5}$ Data (6AM–8PM) during April 7 - May 16

Year	2019	2018	2017	2016
2020	Lower at $\alpha=0.01$	Lower at $\alpha=0.01$	Lower at $\alpha=0.01$	Lower at $\alpha=0.01$
2019		Higher at $\alpha=0.01$	Higher at $\alpha=0.01$	Higher at $\alpha=0.01$
2018	Lower at $\alpha=0.01$		Lower at $\alpha=0.01$	No Statistical Difference
2017	Lower at $\alpha=0.01$	Higher at $\alpha=0.01$		No Statistical Difference
2016	Lower at $\alpha=0.01$	No Statistical Difference	No Statistical Difference	

Table 6. AOD₅₅₀ Values (Both Aqua and Terra Satellite) during Study Period in Dhaka

Platform	Date	Daily Mean AOD ₅₅₀					Relative Changes (%)			
		2016	2017	2018	2019	2020	A	B	C	D
Terra	March 1- May 16 (77 days)	0.94	0.87	0.90	0.91	0.66	-29.8	-24.1	-26.7	-27.8
	April 7- May 16 (40 days)	0.89	0.82	0.87	0.90	0.46	-48.3	-43.9	-47.1	-48.9
Aqua	March 1- May 16 (77 days)	0.75	0.77	0.76	0.80	0.64	-14.7	-16.9	-15.8	-20.0
	April 7- May 16 (40 days)	0.68	0.69	0.71	0.75	0.53	-22.0	-23.2	-25.4	-29.3
Terra+	March 1- May 16 (77 days)	0.86	0.82	0.84	0.87	0.59	-31.8	-28.5	-30.4	-32.6
Aqua	April 7- May 16 (40 days)	0.77	0.76	0.78	0.82	0.54	-29.7	-28.5	-30.3	-33.5

Note: A= 2020 vs 2016; B=2020 vs 2017; C= 2020 vs 2018; D= 2020 vs 2019

somewhat higher during this same period. This study evaluated for all five years (2016-2020) the mean hourly average during working hours of 6 AM to 8 PM, employing the Tukey Multiple Comparison test. The 2019 PM_{2.5} values are significantly higher than 2020, 2018, 2017 and 2016 at $\alpha = 0.01$ level. When reviewing this data it was brought to the researcher's attention that there was extensive construction involving the BRT and MRT projects during the time measurement period. Thus the data shows construction added a significant amount to the PM_{2.5} levels. The ratio of the mean for 2019 to 2018 is 1.38; for 2019 to 2017 is 1.23; and 2019 to 2016 is 1.32. Since during the previous three years buses were running on the streets, trucks were restricted from the inner city, and the brick kilns were not operating, this would indicate that the construction was contributing between 23% and 38% of the PM_{2.5} dust during the day in 2019. To determine if the reduction in truck and bus traffic significantly impacted the PM_{2.5} levels, this study evaluated the mean hourly levels during working hours of 6AM to 8 PM. During these hours heavy diesel trucks are restricted from traveling in the Dhaka city and diesel buses were not allowed to operate in 2020. The above statistical analysis demonstrates that these vehicles contribute significantly to the PM_{2.5}. For the 40 days from April 7 to May 16 the 2020 PM_{2.5} average decreased to 44.8 $\mu\text{g}/\text{m}^3$ and is statistically lower at $\alpha = 0.01$ level than the other years. Since construction was not operating and diesel traffic was restricted in 2020, the ratio of the 2020 mean value of 44.8 $\mu\text{g}/\text{m}^3$ to the mean value 2019 of .64 reflects the reduction in PM_{2.5} due to both of these factors, a 36% reduction in PM_{2.5}. The mean ratio for the working hours measured in 2020 to 2018 is .88; 2020 to 2017 is .79; and 2020 to 2016 is .84. Based on this information

the elimination of diesel buses would reduce the PM_{2.5} between 12% and 21%.

Aerosol Optical Depth (AOD)

The aerosol optical depth used in this study, the AOD at 550 nm (AOD₅₅₀), from 2016 to 2020 (March 1 to 16 May) at Dhaka region, Bangladesh is presented in Table 6. There was discontinuity of satellite derived daily AOD values, therefore, both Aqua and Terra satellites data of MODIS instrument are represented here. From the Terra satellite data, the peak AOD₅₅₀ was .94 in 2016 while the lowest peak value was .66 in 2020. From the Aqua satellite the peak value was .80 in 2019 and lowest peak value .64 in 2020. During the COVID-19 general holiday in 2020, the AOD₅₅₀ value reported from the Terra satellite was .46 and .53 reported from the Aqua satellite. During April 7- May 16, the 2020 values are 48.9 and 29.3% of the 2019 values; 47.1 and 25.4% of the 2018 values; 43.9 and 23.2% of the 2017 values; and 48.3 and 22% of the 2016 values were less for both terra and aqua satellites respectively. The AOD₅₅₀ ratio of aerosol reported from the Terra satellite is higher than the Aqua satellite data. The mean AOD₅₅₀ for both Aqua+Terra was .54 during the 40 day April 7 to May 16 time period in 2020 denotes the aerosol concentration reduction of 33.5%, 30.3%, 28.5%, 30.4% and 29.7% in Dhaka mega city compared to previous four years respectively. This is in agreement with a media report that on March 25, 2020, the AOD₅₅₀ value was 0.3 over north India and fell to 0.2 around April 1 and 0.1 on April 5 (Kapil, 2020). The observed reduction in the Dhaka region might be attributed to anthropogenic activities, though meteorological factors may have contributed. During the COVID-19 general holiday, different emission sectors such as most industries, businesses, residential and commercial construction activities were closed. Additionally, traffic was largely

reduced and people were restrained to their homes attributing to a dramatic decline of the aerosol values in the atmosphere.

CONCLUSION

A dramatic reduction was observed in the MODIS AOD₅₅₀ data during the general holiday period established by the government during this time. AOD₅₅₀ concentration reduced between 28.5% and 33.5% (Terra+Aqua) from the previous four years (2016-2019) from April 7 to May 16 in Dhaka mega city. During the working hours of 6AM to 8 PM over this same time period in 2020 the PM_{2.5} average decreased to 44.8 µg/m³. This is statistically lower at $\alpha = 0.01$ confidence level than for 2016, 2017, 2018, and 2019. The ratio of the 2020 mean value of 44.8 µg/m³ to the mean value of 2019 is 63.7% reflecting the reduction in PM_{2.5} due to restricted construction and diesel travel. Based on the PM_{2.5} hourly data collected from the AQI monitoring station located at the US Embassy it can be concluded that both constructions associated with the BRT and MRT as well as diesel emissions from buses contribute significantly to the air pollution in portions of Dhaka city. Construction from the BRT and MRT may contribute as much as 35% of the PM_{2.5} airborne dust. Diesel buses may contribute as much as 21% of the PM_{2.5} airborne dust. As a result of this study an investigation into construction dust control measure should be initiated by the government. The use of frequent watering with water trucks near major roadways would reduce airborne dust. Dust curtains placed near each of major project would lessen airborne dust. The government could require all buses be converted to a cleaner operating fuel system, such as CNG or electric operation and retire the old diesel buses. This would greatly improve air quality particularly between 6 AM and 8 PM when people are most often on the streets and roads of Dhaka city.

AUTHOR CONTRIBUTIONS

A.A. Nayeem has performed the paper conceptualization, methodology, investigation and writing the draft. A. K. Majumder has done the methodology, writing, editing and visualization. W.S. Carter helped in the formal analysis, revised the draft manuscript and overall supervision.

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CONFLICTS OF INTEREST

The authors declare that there is not any conflict of interests regarding the publication of this manuscript. In addition, the ethical issues, including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, and redundancy has been completely observed by the authors.

ABBREVIATIONS

α	Level of significance
%	Percentage
\$	Dollar
µg/m ³	Microgram per cubic meter
AOD	Aerosol Optical Depth
ADB	Asian Development Bank
AQI	Air Quality Index
BRT	Bus Rapid Transit
CNG	Compressed Natural Gas
DB	Deep Blue
GDP	Gross Domestic Product
IEDCR	Institute of Epidemiology Disease Control and Research
ILO	International Labour Organization
MODIS	Moderate Resolution Imaging Spectroradiometer
MRT	Mass Rapid Transit
NASA	National Aeronautics and Space Administration
nm	Nanometer
PM _{2.5}	aerodynamic diameter of particles ≤2.5 µm

USEPA United States Environmental Protection Agencies
WHO World Health Organization

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ORIGINAL RESEARCH PAPER

Exploring relationship between the development of small and medium scale enterprises and the employment of universities graduate

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ABSTRACT

BACKGROUND AND OBJECTIVES: Over recent years the employment creation discussion was massively raised especially about university graduates and demands from Iran's government increased. The prediction of the youth unemployment rate during the period from 2015 to 2021 showed that with an annual growth rate of 5%, in the last year of the period, the unemployment rate for youth would be equal to 9.36%, and for university graduates will be 36%. Therefore, the main purpose of this research is to provide an applied model for small and medium-sized enterprise (SME) development and university graduates' employment in Iran.

METHODS: In this regard, an appropriate model was defined by studying the literature about small and medium enterprises development models and extracting effective factors according to Iran's situation. In the second stage, after selecting a sample of 60 small and medium enterprises in Iran, in order to quantitatively testing the model, the data were collected by a questionnaire and were analyzed with the help of PLS software. In the third stage, the relative importance of factors were tested from the perspective of 10 experts in the field of entrepreneurship with more than 15 years of work experience with the help of ANP and PROMETHEE methods.

FINDINGS: The results shows the preference value (Φ) of these factors respectively include the parameters of: Technology, innovation, and competitiveness ($\Phi=0.72$); Financial support programs ($\Phi=0.63$); Education and consultancy services ($\Phi=0.38$); Cooperative relationships ($\Phi=0.41$); and Export development ($\Phi=0.55$).

CONCLUSION: Changing market conditions enable SMEs to respond more agile and faster to customer needs, improve the quality of their products, reduce the cost of their production, and their tendency to recruit university graduates.

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INTRODUCTION

The mission of each university is to contribute to the economic, social, cultural, and political development of a society at the regional, national and international levels. Universities carry out this mission by developing human resource besides organizational, social, and cultural capabilities through boosting innovation and innovative entrepreneurship. The development of these capabilities in university students and graduates besides their influence on the economic development of society has been analyzed in human capital theory. According to this theory, the main goal of individuals to demand higher education is to achieve better jobs and higher incomes in the future. On the other hand, employers expect to improve their businesses by recruiting well-educated graduates, increase their productivity and gain higher profits. The small and medium enterprises (SMEs) can be very effective in creating sustainable employment, especially for university graduates, youth, and women since they attract the natural growth of a society's workforce, as well as employing the fired workforce of private organizations (Entezari, 2016). One of the major causes of long-term unemployment in developing countries is the deficiency of the business environment. Such a condition leads to an increase in the intermediary sector's cash flow, which results in lower production, increasing inflation and unemployment. In the recent years, the topic of university graduates' employment has been an extremely challenging issue, and accordingly, the demands for job creation, especially for university graduates, have increased. The prediction of the youth unemployment rate during the period from 2015 to 2021 shows that with an annual growth rate of 5%, in the last year of the period, the unemployment rate for youth will be equal to 9.36%, and for university graduates will be 36% (Mozayyeni, 2017). SMEs, including micro enterprises (enterprises with fewer than 10 employees), have a significant effect on a country's economic and industrial development (Garcia-Perez-de-Lema *et al.*, 2017; Saridakis *et al.*, 2018). SMEs, so-called the backbone of the private sector, are accounted for 90% of the world's total companies (Ormazabal *et al.*, 2018) and between 50% and 60% of the share of employment (Mamman *et al.*, 2019). In Iran, about 80% of the economy is based on large governmental

and semi-governmental organizations. Extraction, processing, and trading of oil, petrochemicals, and gas alone account for 80% of Iranian exports and 40% to 50% of the government's budget. Contrary to the fact that most Iranian businesses are SME, Iran's economy is heavily dependent on large public corporations (UNIDO, 2003). Benefits of SMEs are: 1) mobilizing all national resources of a country to create job opportunities, generate wealth and thus reduce poverty, 2) exploiting the potential of the disadvantaged population of society, especially youth and women, to the benefit of the country's economic development, 3) implementing the government's policy of privatization based on Iran's constitution and exploiting the capacity of SMEs as a way to absorb the surplus of the unemployed labor caused by the implementation of this law, 4) promoting the culture of motivating and taking entrepreneurs' participation in economic, political, and social activities of the country, and 5) taking advantage of the remarkable innovation and flexibility of the SMEs in responding to the changing environment compared to large enterprises. Considering the benefits of SMEs, this sector is recognized as a job creator engine for university graduates in a society (Mamman *et al.*, 2019). Successful examples in all types of economies (developed, developing, and in transition) have highlighted the fact that the sustainable development of SMEs and the employment of university graduates are fulfilled when two vital elements in the business environment are available. The first element is creating a suitable legal structure for SMEs to help them develop and the second element is creating an appropriate environment for SMEs to help them become more competitive compared to large-sized enterprises (LSEs), like providing SMEs with business consultancy services, training programs, financial services and likewise (Bodlaj *et al.*, 2018; Falk and Figueira de Lemos, 2019). The result of all of these efforts is to create more jobs for university graduates and increase the GDP of society (Mamman *et al.*, 2019). What is apparent is assessing SMEs' business environment and solving its problems are the prerequisites in order to improve GDP and create job opportunities for university graduates. Therefore, before any action and policymaking, assessing the business environment is necessary in order to find barriers. Consequently, in this research,

based on the previous literature, the role of SMEs development and university graduates' employment determinants were categorized, whereas insufficient researches were done regarding the issue of SMEs and employment for graduates of universities in Iran, taking the impact of cooperative relationships and internationalization factors into consideration. The main concern of this research is to answer the question that "what are the main factors of SMEs development and the university graduates' employment in Iran?" Precisely, this study is about to seek university graduates' employment drivers through empowering SMEs. Thus, a comprehensive model for the development of SMEs and university graduates' employment considering Iran's situation in order to be applicable in designing, implementing, developing, and guiding SME clusters in various industries in Iran even in the form of home businesses and family workshops was provided. In the following section, literature review is examined according to this issue.

Literature review

As Entezari (2016) points out, the expectation of policymakers, likewise, is that first, by increasing in the well-educated graduates' share of the total employment, GDP increases. Second, well-educated graduates are expected to be not only self-employed but also create new job opportunities for other people. In Iran, the excessive increase in the number of higher education institutions until 2013 not only has not helped solving the society's problem of unemployment, but it also caused new problems, such as the high number of well-educated unemployment, excessive job expectations, and an increase in the emigration of educated people known as the brain drain phenomenon (Mozayyeni, 2017). According to the Institute of Research and Planning in Higher Education, (2018), there are totally 2468 education institutions and 3 million 794 thousand and 420 students studying in these institutions. In the current situation, providing a solution to the growth and development of graduates' employment and reducing the costs imposed on the country by that is necessary. According to the UNIDO, (2003), in developing economies, the SME sector is the only realistic way of realizing the vision for increasing employment and creating added value. Therefore, the purpose of this research in order to develop the

SME sector and create jobs for university graduates leads to the following hypotheses:

Hypothesis, 1: Technology-oriented, innovative, and competitive SMEs are likely to create more employment for university graduates

According to Porter's diamond theory on the competitiveness of nations and industries, countries can create competitive advantages through numerous factors, including the promotion of technology in the industry, training the skillful technical workers and government support of the economy (Özer *et al.*, 2012). In many countries, the government's policy of creating jobs for university graduates is to strengthen SMEs through focusing on improving competitiveness, innovation, and technology levels of these businesses (UNIDO, 2003). According to Saridakis *et al.*, (2018) and Latifian (2006), several methods, including computerization of production operations and the establishment of supportive structures for encouraging SMEs to implement automation and set up databases contributes to an increase in the competitiveness of SMEs and their willingness to employ well-educated, specialized labor. In addition, several articles refer to the allocation of low-interest loans to SMEs as a way of encouraging them to automate, expand activities, and increase tendency to employ well-educated workforce (Malek Saeedi *et al.*, 2017; Rahnavard and Hussein, 2005; Tayyebi *et al.*, 2010). On the other hand, the UNIDO, (2003) has also insisted on the importance of providing SMEs with training workshops to encourage them to use technology. Therefore, SMEs which use new technologies require specialized labor. Limaj and Bernroider (2019), along with several other scholars, emphasize the need to provide SMEs with specialized technical staff and facilitate their access to technical services (Amini, 2015; Malek Saeedi *et al.*, 2017). Also, Jernström *et al.*, (2017) and Giotopoulos *et al.*, (2017) state that SMEs that have developed R&D programs in collaboration with universities and other private research institutes have shown greater stability in competing in different markets. Finally, Rahnavard and Hussein (2005) argue that implementing incentive schemes for the industrial development of SMEs through attracting foreign investment in technology helps to improve SMEs' competitiveness and create job opportunities for university graduates.

Hypothesis, 2: The employment of university graduates is likely to be increased by the development of financial support programs for SMEs

So far, the effect of financial issues on the job creation potential of SMEs has been studied by many researchers. According to Amini (2015), the provision of the necessary financial resources for SMEs through venture capital companies leads to an increase in the capital of these businesses and, thus, the employers' tendency to recruit new employees, especially well-educated ones. Several articles focus on facilitating laws about allocating low-interest loans to SMEs and implementing incentive tax schemes as a way to encourage entrepreneurs to set up new businesses and, thus, creating new jobs for university graduates (UNIDO, 2003; Malek Saeedi *et al.*, 2017; Rahnavard and Husseini, 2005; Amini, 2015). For example, Amin Aghai (2008) argued that SMEs' financial constraints, their use of financial facilities, such as low-interest loans, and the amount of taxes they pay to the government and the municipality contributes to the employers' tendency to recruit new workers. On the other hand, the UNIDO, (2003) states that the establishment of entrepreneurship centers with the aim of launching, supporting, and guiding new startups can encourage entrepreneurs to set up new businesses and increase self-employment who seek to take advantage of entrepreneurship centers' benefits. Eventually, Malek Saeedi *et al.*, (2017), along with several other scholars, emphasize the need to provide SMEs' with low-interest loans. They argue that SMEs that have more financial resources can develop their activities and, thus, generate more employment (Rahnavard and Husseini, 2005; Tayyebi *et al.*, 2010).

Hypothesis, 3: The development of education and consultancy services for SMEs is likely to contribute to the development of employment for university graduates

Amini (2015) described the main characteristics and challenges of Iran's labor market, amongst which are the high unemployment rate of university graduates, the continuing unemployment, the inappropriate universities' educational content according to the needs of the country's labor market and the unskillful workforce. Then, in order to reduce the unemployment rate, it was recommended to focus on training skillful workforce. On the other

hand, Movvahedi (2017), Amini (2015) and Garcia-Perez-de-Lema *et al.*, (2017), in various studies stated the need to organize training workshops for university graduates as the potential labor with the aim of empowering them through providing applicable skills appropriate to the labor market's needs. According to Limaj and Bernroider (2019) and some other researchers, the development of educational programs in the form of workshops for managers and technical staff with the aim of training innovation in managerial and technical levels is necessary for raising SMEs' innovativeness (Rahnavard and Husseini, 2005; Parsapour *et al.*, 2017; Garcia-Perez-de-Lema *et al.*, 2017; Amini, 2015; Movvahedi, 2017). In addition, Movvahedi (2017) states that SMEs' consultancy centers, by providing professional and customized advisory services, enable SMEs to find effective solutions to their problems and encourage entrepreneurs to create sustainable jobs. On the other hand, the UNIDO, (2003) highlights registering products and facilities, needed by SMEs, in an integrated public tender system allows SMEs to take advantage of the tender bids' benefits formally, reduces the total cost of production, and increases employers' tendency to recruit new people.

Hypothesis, 4: SMEs with more developed cooperative relationships are likely to create more job opportunities for university graduates

In the face of a changing competitive environment, SMEs are looking for ways to grow sustainably, expand their operations, and become more competitive. In such a situation, the development of communication networks is a critical factor in promoting their performance and creating job opportunities (Lin and Lin, 2016). The development of communication networks through the establishment of cooperative relationships between SMEs with LSEs, suggested by many researchers, is required to promote SMEs' performance and enhance employment. The UNIDO (2003) emphasizes that the government should encourage LSEs to engage in voluntary activities in relation to SMEs by supplying raw materials and playing roles in their production process. On the other hand, Lin and Lin (2016) argue that the advantages of cooperating with LSEs provide SMEs with the opportunity to access technology, strengthen SMEs' weaknesses, reduce costs and risk of transactions, increase SMEs' market reputation, share knowledge,

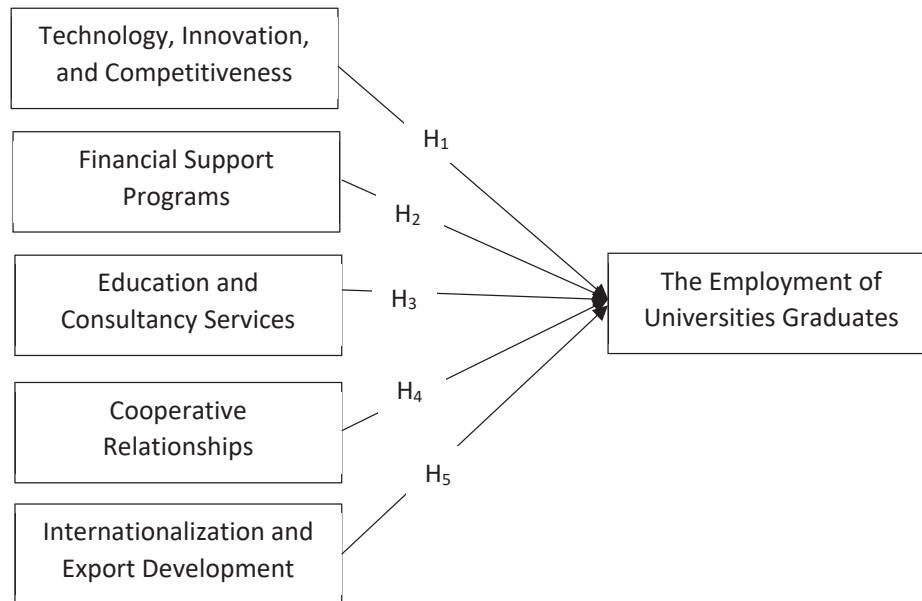


Fig. 1. The theoretical model

gain new opportunities in the market, and the acceleration of innovation. In addition, LSEs play an important role in linking SMEs to international markets via their overseas branches (Jernström *et al.*, 2017; Lin and Lin, 2016; Latifian, 2006; Saridakis *et al.*, 2018; Movvahedi, 2017). On the other hand, establishing cooperative relationships between SMEs in the same or affiliated industries or, in other words, creating SME clusters is essential because it leads to the gathering of a number of SMEs in industrial parks and taking advantage of the other facilities and technologies. Advantages like cooperating in buying raw materials and gaining market trust lead to a dramatic boost in SMEs' competitiveness, since the formation of SME clusters increases the ability of each enterprise in accessing more extended distribution systems, new technologies, and new products development (Lin and Lin, 2016; Chen *et al.*, 2017). UNIDO (2003) also highlighted the need for the creation of a lobbying mechanism in favor of the SME sector against the government in the form of SME clusters. Finally, Garcia-Perez-de-Lema *et al.*, (2017), along with Limaj and Bernroider (2019), emphasize the need for improving the cooperative relationships between SMEs and universities which leads to an enhancement in performance and innovation of SMEs.

Hypothesis, 5: SMEs' internationalization and export development may promote employment for university graduates

According to Vernon (1966, 1971, 1979) research about product life cycle theory (PLC), the process of globalization is a sequent of product life cycle. Companies first offer their products to local markets and thereby obtain feedback about their performance, then they can export their products to foreign markets, expand activities, and increase their employment potential. According to the UNIDO, (2003), the biggest problem faced by SMEs in terms of employment is the lack of market knowledge and the experience of international trade. Therefore, in order to increase the capacity of SMEs to create employment, the government needs to teach them export experience through providing related training, consulting services, and connecting them with foreign buyers (UNIDO, 2003). According to Giotopoulos *et al.*, (2017), the government can, by providing information about foreign exhibitions, encourage SMEs to play a prominent role in international markets. Inspired by the results of previous literature, the importance of developing SMEs for the employment of university graduates is obvious. Despite the fact that previous researches have consistently emphasized the critical role of SMEs not only in employment but

also in GDP growth, mostly the role of technology, innovation, competitiveness, financial support, and education were studied by national scholars, thus, the potential impact of cooperation and export development especially in the Iranian environment were less considered. In the present study, with the help of gathering many factors, an applicable model for developing SMEs and employment for university graduates, as shown in Fig. 1. The current study have been carried out in Boroujerd's industrial park in 2018.

MATERIALS AND METHODS

Data collection and sample

In this section, in order to achieve the research's objectives, the hypotheses were examined. Therefore, the place of study, sampling method, data collection, method of measuring variables, research tools and data analysis methods were described. By purpose, this cross-sectional research is a qualitative one and, by the method, this survey-based research is a descriptive one. To assess the hypotheses, data were collected in Iran from SMEs operating in the industrial parks by the use of convenience sampling method through questionnaires. To collect data, two questionnaires were designed through the study of literature, dissertations, articles, and databases related to the research's topic (in national and international level). The first questionnaire was designed to test the theoretical model for university graduates' employment creation. It was arranged based on the Likert scale and assessed the perspective of 60 entrepreneurs that employed between 10 and 249 people. The model was confirmed by the PLS software. Subsequently, the second questionnaire, using the pairwise comparisons, determined the relative importance of the model's factors from the perspective of 10 experts in the field of entrepreneurship with more than 15 years of work experience. Therefore, in the present research, the field method was used to determine the key factors and confirm the theoretical model, the factors were weighed using the ANP method and were ranked using the PROMETHEE method. In the following section, these methods are explained.

Research instrument

The power of the relations between the latent variable and the observable variable is defined by

the factor loading (λ). The value of factor loading is defined between zero and one. If the factor loading is less than 0.3, the relation between the variables is considered weak and is discarded. However, the acceptable value of factor loading is between 0.3-0.6 and values greater than 0.6 are desirable. In factor analysis, variables that measure a latent variable must have high factor loadings with that latent variable, and low factor loadings with other latent variables. The t-test is used to evaluate the significance of the relations between the variables with a significant level of 0.05. Therefore, if the t-value is calculated less than 1.96, the relation is not significant (Gorsuch, 1983). The analytic network process (ANP) is a more general form of the analytic hierarchy process (AHP) process used in multi-criteria decision analysis (MCDM). The ANP structures a decision problem into a network then use a system of pairwise comparisons to measure the weights of the components of the structure, and finally to rank the alternatives in the decision. The first step in the ANP method is creating a model and structure of the problem. The problem should be expressed clearly and be analyzed into a logical system like a network. Such a network structure can be achieved with the help of decision makers through brainstorming sessions or other appropriate methods. In the second step, pairwise comparisons are used to find out how the elements in the network are interacting (Saaty, 1996). The weights used at this stage are the input values to indicate the priorities of each criterion and sub-criterion in the PROMETHEE method. PROMETHEE method is a multi-criteria decision-making methodology designed to discuss qualitative and discrete alternatives (Brans et al., 1986). This method is quite simple compared to other multi-criteria analysis methods, and it is especially appropriate for issues that require a limited number of actions to be ranked based on several criteria that are sometimes contradictory. This approach can be one of the most powerful decision-making methods that can help managers choose the best decision choices. The ranking of actions is performed by comparing the pair of actions in each criterion. The comparison is measured based on a predefined preference function with the domain [0, +1]. The preference function P is a function which compares two actions "a" and "b" in terms of the criterion j as Eq. 1:

$$P_j(a, b) = P[d_j(a, b)] \quad (1)$$

$d_j(a, b) = f_j(a) - f_j(b)$ denotes the difference in the size of two actions for criterion f_j . This difference for criteria that have to be maximized will be significant only if $f_j(a) > f_j(b)$. For the criteria that have to be minimized, the opposite condition is true. When a preference function has been associated with each criterion by the decision maker, all comparisons between all pairs of actions can be done for all criteria. A multi-criteria preference degree is then computed to globally compare every couple of actions as Eq. 2:

$$\Pi(a, b) = \frac{\sum_{i=1}^k \pi_i P_i(a, b)}{\sum_{i=1}^k \pi_i} \quad (2)$$

In order to position every action with respect to all the other actions, two scores are computed as shown in Eq. 3 and Eq. 4:

$$\varphi^+(a) = \sum_{b \in k} \Pi(a, b) \quad (3)$$

$$\varphi^-(a) = \sum \Pi(a, b) \quad (4)$$

The positive preference flow quantifies how a given action is globally preferred to all the other actions while the negative preference flow quantifies how a given action is being globally preferred by all the other actions. The positive and negative preference flows are aggregated into the net preference flow as Eq. 5:

$$\varphi(a) = \varphi^+(a) - \varphi^-(a) \quad (5)$$

This is the PROMETHEE II complete ranking which is obtained by ordering the actions according to the decreasing values of the net flow scores. In other words, the criterion with the highest net flow has priority (Brans *et al.*, 1986).

RESULTS AND DISCUSSIONS

The PLS Output

Table 1 shows the output of PLS software which contains the factor loadings of the model's criteria. As mentioned, factor loadings above 0.3 are acceptable and criteria with factor loadings lower than 0.3 are excluded. According to the results, all model's factors were confirmed. Also, the t-value was extracted as follows which were all greater than 1.96, and thus, acceptable.

Weight measurements and ranking the model's criteria and sub-criteria using ANP and PROMETHEE methods

After designing a network of the model in Super Decision software and entering the data collected from questionnaires, the weights of all criteria were calculated. In the second stage, in order to rank criteria, the value of the index Φ was calculated by PROMETHEE software. Based on the outputs, the model's inconsistency was 0.08, which is less than 0.1, so the system's consistency was confirmed. Due to the system compatibility, the data of the paired comparisons was introduced into the Super Decision software and calculate the weight of each of the factors. The output of this part is shown in Table 2.

Given the output of PROMETHEE software, the value of Φ for the first criterion, which is technology, innovation, and competitiveness, was 0.72 and more than other criteria. Therefore, it was the most prior criterion. By assessing each sub-criterion of each factor, the weight and rank of each sub-criterion was extracted. In the next step, the weight associated with the indicators for the development of technology, innovation, and competitiveness were calculated. By performing Super Decision software, the value of inconsistency for "technology, innovation, and competitiveness" criterion was equal to 0.04, which is less than 0.1, so the system's consistency was proven. In the following, the weight of the sub-criteria of this element using Super Decision and ranking them using the PROMETHEE software were calculated. The result is shown in Table 3.

The findings which followed the main stream literature, reveal that empowering SMEs to be able to develop technology, innovation and competitiveness through activities such as allocating low-interest loans to encourage automation, launching databases, providing SMEs with workshops about how to use technology, providing SMEs with technical expertise, investing in R&D projects with help of universities and other training centers, and implementing promoting plans for attracting foreign direct investment and joint venture capital in the field of technology to enhance SMEs. Aforementioned activities, according to experts, in today's changing market conditions enable SMEs to respond more agile and faster to customer needs, improve the quality of their products, reduce the cost of their production, and increase tendency to recruit new labor. Therefore,

Table 1. The PLS software output for t-values and factor loadings of the research model's criteria

Latent variables	Observable variables	T-value	Factor loading	Confirmed/Not confirmed
Technology, innovation, and competitiveness	Allocating low-interest loans to encourage automation	109.295	0.950	✓
	Launching a centralized database of R&D projects and technologies accessible to SMEs	219.216	0.985	✓
	Providing SMEs with workshops about how to use technology	61.976	0.942	✓
	Providing SMEs with technical expertise	126.641	0.965	✓
	investing in R&D projects with the help of universities and other training centers	315.021	0.983	✓
	Implementing promoting plans for attracting foreign direct investment and joint venture capital in the field of technology	194.138	0.978	✓
	Incentive tax schemes to encourage entrepreneurs setting up startups	113.366	0.970	✓
Financial support programs	The establishment of entrepreneurship centers in order to support and guide the startups	571.361	0.991	✓
	Facilitating laws about allocating low-interest loans to SMEs	91.308	0.947	✓
	Establishing venture capital companies to finance SMEs	82.590	0.961	✓
Education and consultancy services	Allocating low-interest loans to SMEs	89.471	0.965	✓
	delivering innovation workshops to managers	763.940	0.993	✓
	Delivering innovation workshops to technical staff	414.068	0.988	✓
	Training workshops for university graduates	242.465	0.977	✓
	Establishing consultancy centers for the SME sector	111.772	0.973	✓
	Setting up a public tender system for SMEs (SMEs' accessibility to lower cost products and services)	912.183	0.995	✓
	The improvement of cooperative relationships between SMEs and LSEs (as potential suppliers and potential foreign relationships mediators)	344.874	0.986	✓
Cooperation relationships	The improvement of cooperative relationships between SMEs in the same or affiliated industries in the form of SME clusters	181.132	0.980	✓
	The improvement of cooperative relationships between universities and SMEs in order to enhance the performance and innovation of the SME sector	549.928	0.990	✓
	The creation of a lobbying mechanism in favor of the SME sector against the government	181.274	0.981	✓
	Implementing incentive schemes to increase exports by providing training workshops to learn market knowledge and export experience	623.483	0.992	✓
Internationalization and export development	Implementing incentive schemes to increase exports by delivering advisory services and connecting SMEs to foreign buyers	598.793	0.992	✓
	Implementing incentive schemes to increase exports by providing information about foreign exhibitions and encouraging SMEs to participate in foreign exhibitions	258.541	0.986	✓

the obtained results clearly confirmed the impact of the above factors on university graduates' employment. So, the first hypothesis (H_1), that is technology-oriented, innovative, and competitive SMEs can create more employment for university graduates, was true. Given the output of PROMETHEE software, the value of Φ for the first criterion, which

is implementing promoting plans for attracting foreign direct investment and joint venture capital in the field of technology, was 0.65 that was more than other sub-criteria. Therefore, it was the most prior sub-criterion of technology, innovation, and competitiveness. By performing Super Decision software, the value of inconsistency for "financial

Table 2. The model's main factors' weights and ranking

Factor	Weight	Φ	Rank
Technology, innovation, and competitiveness	0.45	0.72	1
Financial support programs	0.32	0.63	2
Education and consultancy services	0.07	-0.38	3
Cooperation relationships	0.12	-0.41	4
Internationalization and export development	0.04	-0.55	5

Table 3. The weight and ranking of sub-criteria relative to the factor of technology, innovation, and competitiveness

Sub-criterion	Weight	Φ	Rank
allocating low-interest loans to encourage automation	0.06	-0.46	4
launching databases	0.27	0.60	2
providing SMEs with workshops about how to use technology	0.23	0.49	3
providing SMEs with technical expertise	0.04	-0.60	5
investing in R&D projects with help of universities and other training centers	0.02	-0.68	6
implementing promoting plans for attracting foreign direct investment and joint venture capital in the field of technology	0.38	0.65	1

Table 4. The weight and ranking of sub-criteria relative to the factor of Financial support programs

Sub-criterion	Weight	Φ	Rank
incentive tax schemes to encourage entrepreneurs setting up startups	0.16	-0.27	3
the establishment of entrepreneurship centers in order to support and guide the startups	0.04	-0.62	5
facilitating laws about allocating low-interest loans to SMEs	0.29	0.41	2
establishing venture capital companies to finance SMEs	0.06	-0.58	4
allocating low-interest loans to SMEs	0.44	0.61	1

support programs" criterion was equal to 0.05, which is less than 0.1, so the system's consistency was proven. In the following, the weight of the sub-criteria of this element using Super Decision and ranking them using the PROMETHEE software were calculated. The result is shown in Table 4.

The research also emphasized the undeniable role of developing financial support in empowering the SME sector. With regard to the importance of this issue, experts point out despite the fact that financial constraints positively contribute to innovation enhancements in SMEs (Bodlaj, 2018), the employers' tendency to hire new workforce decline since the SMEs' total capital is restricted. Therefore, due to the aim of this research, financial support in the form of incentive tax schemes to encourage entrepreneurs setting up startups, the establishment of entrepreneurship centers in order to support and guide the startups, facilitating laws about allocating low-interest loans to SMEs, establishing venture capital companies to finance SMEs and allocating low-interest loans to SMEs lead to an increase in the

total capital of SMEs and, thus, encourage employers to recruit new staff especially well-educated ones. Therefore, the second hypothesis (H_2), which is the employment of university graduates can be increased by the development of financial support programs for SMEs, was confirmed. Given the output of PROMETHEE software, the value of Φ for the first criterion, which was allocating low-interest loans to SMEs, was 0.61 and more than other sub-criteria. Therefore, it was the most prior sub-criterion of financial support programs. By performing Super Decision software, the value of inconsistency for "education and consultancy services" criterion was equal to 0.09, which is less than 0.1, so the system's consistency was proven. In the following, the weight of the sub-criteria of this element using Super Decision and ranking them using the PROMETHEE software were calculated. The result is shown in Table 5.

Confirmed by the main stream literature, experts point out the insufficient accessibility of employers to employees who are well-trained, skillful, and familiar

Table 5. The weight and ranking of sub-criteria relative to the factor of Education and consultancy services

Sub-criterion	Weight	Φ_a	Rank
delivering innovation workshops to managers	0.47	0.72	1
delivering innovation workshops to technical staff	0.15	-0.134	4
training workshops for university graduates	0.22	-0.007	2
establishing consultancy centers for the SME sector	0.05	-0.46	5
setting up a public tender system for SMEs (SMEs' accessibility to lower cost products and services)	0.11	-0.126	3

Table 6. The weight and ranking of sub-criteria relative to the factor of Cooperation relationships

Sub-criterion	Weight	Φ	Rank
the improvement of cooperative relationships between SMEs and LSEs (as potential suppliers and potential foreign relationships mediators)	0.49	0.65	1
the improvement of cooperative relationships between SMEs in the same or affiliated industries in the form of small and medium clusters	0.17	-0.17	3
the improvement of cooperative relationships between universities and SMEs in order to enhance the performance and innovation of the SME sector	0.05	-0.84	4
the creation of a lobbying mechanism in favor of the SME sector against the government	0.29	0.33	2

with the environment of industries. They believe it is possible to provide educational content appropriate for the needs of the market to university graduates in order to increase the employers' tendency to hire well-educated individuals. In their opinion such education contents can be delivered in the form of training workshops for university graduates, delivering innovation workshops to both managers and technical staff, establishing consultancy centers for the SME sector, setting up a public tender system for SMEs (SMEs' accessibility to lower cost products and services). Experts emphasize that the purpose of such a comprehensive tender system is to set up a system where SMEs can easily find suppliers with lower prices, as an example. Thus, by decreasing total costs, the desire to develop activities and the need to hire new staff increases. Consequently, the third hypothesis (H_3) was approved. Given the output of PROMETHEE software, the value of Φ for the first criterion, which was delivering innovation workshops to managers, was 0.72 and more than other sub-criteria. Therefore, it was the most prior sub-criterion of education and consultancy services. By performing Super Decision software, the value of inconsistency for "cooperative relationships" criterion was equal to 0.07, which is less than 0.1, so the system's consistency was proven. In the following, the weight of the sub-criteria of this element using Super Decision and ranking them using the PROMETHEE software were calculated. The result is shown in Table 6.

Emphasized by the result of this study and followed by the main stream literature, the positive impact of cooperative relationships on creating job opportunities for university graduates was approved. The relative significance of this factor has been evaluated in the third place, but in the opinion of the experts its vital role in the development of the SME sector shouldn't be underestimated since the necessity of communication and cooperation in today's modern world in implementing various business plans and accelerating the development of SMEs and, thus, increasing job opportunities for well-educated people is indisputable. They acknowledge that cooperative relationships help the stability and the development of SMEs through the improvement of cooperative relationships between SMEs and LSEs (as potential suppliers and potential foreign relationships mediators), the improvement of cooperative relationships between SMEs in the same or affiliated industries in the form of small and medium clusters in order to increase the bargaining power of purchasing, the development of new products and the development of new technologies, the improvement of cooperative relationships between universities and SMEs in order to enhance the performance and innovation of the SME sector, and the creation of a lobbying mechanism in favor of the SME sector against the government. They believe that establishing cooperative relationships between the SME clusters and LSEs leads to access to some

Table 7. The weight and ranking of sub-criteria relative to the factor of Internationalization and export development

Sub-criterion	Weight	Φ	Rank
Implementing incentive schemes to increase exports by providing training workshops to learn market knowledge and export experience	0.49	0.17	1
Implementing incentive schemes to increase exports by delivering advisory services and connecting SMEs to foreign buyers	0.20	-0.17	3
Implement incentive schemes to increase exports by providing information about foreign exhibitions and encouraging SMEs to participate in these exhibitions	0.31	0.00	2

kind of facilities especially for SMEs in the form of raw material procurement, the use of experience in purchasing new tools, the use of experience and training of the staff, and pay back to LSEs in the form of delivering orders in exchange for receiving services instead of paying back in cash, LSEs' participation in a percentage of SMEs' profit margin in exchange for delivering services instead of being paid in cash. Thus, employers tend to develop activities and need more staff. Therefore, the fourth hypothesis (H_4), which is SMEs with more developed cooperative relationships can create more job opportunities for university graduates, was confirmed.

Given the output of PROMETHEE software, the value of Φ for the first criterion, which was the improvement of cooperative relationships between SMEs and LSEs (as potential suppliers and potential foreign relationships mediators), was 0.65 and more than other sub-criteria. Therefore, it was the most prior sub-criterion of cooperative relationships. By performing Super Decision software, the value of inconsistency for "internationalization and export development" criterion was equal to 0.05, which is less than 0.1, so the system's consistency was proven. In the following, the weight of the sub-criteria of this element using Super Decision and ranking them using the PROMETHEE software were calculated. The result is shown in Table 7.

Given the output of PROMETHEE software, the value of Φ for the first criterion, which was implementing incentive schemes to increase exports by providing training workshops to learn market knowledge and export experience, was 0.17 and more than other sub-criteria. Therefore, it was the most prior sub-criterion of internationalization and export development.

The findings, followed the main stream literature, revealed that despite the less-considered role of globalization and export development in scholars (Giotopoulos *et al.*, 2017), particularly national

ones (UNIDO, 2003), and despite its ranking as the fifth important factor, its positive impact on the development of the SME sector is strongly confirmed by this research. With regard to the opinion of experts, the great influence of this factor on the SME sector development, besides its low priority compared to other factors, is justified by the significant increase in the total capital of SMEs due to the difference between the foreign exchange rates and Iran's currency and, thus, its great potential on creating new job opportunities. On the other hand, both the ambiguities in the context of the future of Iran's international banking interactions and the geographical locations of the provinces and their distances to the mutual borders with Iran's neighbor countries affect the low priority of this factor in proportion to others. Therefore, the last hypothesis of this study (H_5), that is the SMEs' internationalization and export development can promote employment for university graduates, was confirmed.

CONCLUSION

In this study, the relationship between technology, innovation, competitiveness, financial and educational support and the development of SMEs, as a job creator engine for university graduates, taking the impact of cooperation and export development, especially in Iran's environment, is investigated. The present study is helpful in collecting a number of factors contributing to the development of the SME sector and employment for university graduates in Iran. The results show that technology development, innovation, and competitiveness of SMEs is a relatively more preferable determinant in creating job opportunities for university graduates. Overall, the findings follow the main stream literature, reveal that empowering SMEs through activities such as the development of technology, innovation and competitiveness, financial support programs, *education and consultancy services*, and

SMEs' internationalization and export development, according to experts, in today's changing market conditions enable SMEs to respond more agile and faster to customer needs, improve the quality of their products, reduce the cost of their production, and their tendency to recruit university graduates.

The results of this research have several management implications at the executive level. Before proceeding executive suggestions, it is important to note that all of the sub-criteria of the model can strongly affect the development of employment for university graduates and their importance cannot be ignored or underestimated. Therefore, in line with the purpose of this research and based on the output obtained, several executive suggestions are presented:

1. Due to empowering SMEs to be able to develop technology, innovation and competitiveness, according to the first hypothesis, setting up a comprehensive tender system to help SMEs find affordable products, services, and technologies is helpful.

2. According to the second hypothesis, which is about the development of financial support programs for SMEs, increasing loans and financial facilities by simplifying the banking systems besides improving the SME sector's funding by promoting the banking system to increase credit lines for industrial SMEs is suggested;

3. Based on the importance of offering education and consultancy services to SMEs, according to the third hypothesis, reorganizing universities' educational content appropriate for the specific needs of SMEs business environment and training efficient technical workforce besides linking graduated university students to SMEs in all industries through comprehensive and transparent databases is helpful;

4. Due to the fourth and the third hypotheses, which relatively emphasized on the role of SMEs' developed cooperative relationships and consultancy services, supporting entrepreneurial and self-employment activities in rural areas by connecting entrepreneurs and consultancy centers at low-cost and simplifying the administrative and legal processes besides establishing the necessary mechanisms for creating new capacities especially for SMEs operating in isolated locations with limited accessibility to raw material resources and encouraging the formation of SME clusters, especially in geographically low-income

regions is suggested;

5. Based on the second and the fifth hypotheses, which relatively emphasized on the development of financial support programs for SMEs and export development, lobbying and influencing governmental decisions to allocate some of its income to implement incentive programs and to promote the export of the SME sector besides modification of incentive and financial privileges like tariffs, taxes, and other export expenditures for all SMEs, especially SMEs in less developed areas, in order to encourage them to increase exports and increase employment creation in these areas is helpful;

6. Due to the importance of SMEs' internationalization in promoting the employment of university graduates, according to the fifth hypothesis, attracting local and foreign investments for the development of R&D projects to the benefit of SMEs is suggested;

The present study, in spite of the importance of its findings to employment creation, has some limitations. This research is based on the cross-sectional convenient sampling method with a focus on SME industries in some industrial parks. Therefore, it is recommended to retest the model with a larger sample of SMEs in order to more accurately generalize the results and reach a more comprehensive viewpoint. Future researches can also evaluate the inclination of executive agencies and the effectiveness of their activities as moderators in the extent of job creation efforts through the SME sector development, considering the role of other factors such as economic indicators. Therefore, studying the impact of these factors on the development of the current model can be beneficial.

AUTHOR CONTRIBUTIONS

Younos Vakil Alroaia performed conceptualization, methodology, software, and literature review and manuscript preparation. Shima Masaali and Dr. Vakil Alroaia performed data correction, writing original draft preparation, writing reviewing and editing references.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest regarding the publication of this manuscript. In addition, the ethical issues, including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, and redundancy have been completely observed by the authors.

ABBREVIATIONS

<i>LSEs</i>	large-sized enterprises
<i>PLC</i>	product life cycle
<i>SMEs</i>	small and medium enterprises
<i>UNIDO</i>	United Nation's Industrial Development Organization

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ORIGINAL RESEARCH PAPER

Influence of road transport quality on urban dwellers' satisfaction

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ABSTRACT

BACKGROUND AND OBJECTIVES: The significance of road mobility in any nation cannot be far-fetched or beyond economic purpose, spatial interaction and social integration. It contributes enormously to the livelihood of human existence most especially by facilitating regional complementarity of trade, intervening opportunities, and spatial transferability. The objective of this study was to examine the influence of road transport quality on urban dwellers' satisfaction in Kogi state, Nigeria.

METHODS: The study adopted a survey research design and systematic sampling method to elucidate primary data through questionnaire from 1215 respondents.

FINDINGS: It was revealed that the status of the road network has an influence on the transport rate charge per trip at a correlation value of 0.998 and significant value of 0.000; and on the comfort derived from the passengers at correlation value of 0.545 and significant value of 0.000. The provision of transport scheme has an influence on the transport rate charge per trip at the correlation value of 0.905 and significant value of 0.000; and on the quality of road transport comfort at a correlation value of 0.523 and significant value of 0.000. The timely response of road maintenance and sub road infrastructure maintenance has an influence on the transport rate charge per trip at a correlation value of 0.545 and significant value of 0.000; and on the quality of road transport comfort at correlation value of 0.912 and significant value of 0.000. The communication link between the agencies in charge of road transport and the people in the study area influences the compliance of road transport operators with road safety rules and regulations at a correlation value of 0.565 and significant value of 0.000.

CONCLUSION: The condition of the vehicle has a great impact on the level of comfort.

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INTRODUCTION

There have been issues that surround the elongation of systems and components that enhance the livelihood of the human being. The systems are energy supply system, water supply system, medical system, sewage disposal system, and transportation system. Also, the damage or disruptions that are attributed to the systems are predominant during natural disasters, such as heavy rainfall, earthquakes, and storms. Among the systems is the transportation system which is the life-wire of any nation because it shoulders and catalyzes the socio-economic and political development of the nation. In the study conducted by Hopkins *et al.*, (1991), it was identified that the transportation system is the most crucial lifeline system because it restores the majority of the other lifeline systems. This study dwells more on road transportation which is among the modes of the transportation system. The modes of transportation available to urban dwellers in Kogi state, Nigeria include road and water transportation. The transport service operating in the area can be categorized into a public passenger bus that is operated and managed by both private and public service providers; private hired vehicles that range from buses to three-wheeler vehicles; personal vehicles such as motor cars among others; cycling and walking. It is pertinent to note that the last category is the policy direction of most developed countries in the actualization of sustainable living because of its significance to health and the environment. The dominant mode of public transport operation in Kogi state is the public transport service which is both managed by the public and private sector. The officials of the sector are saddle with the responsibility of ensuring adequate safety of passengers and vehicles used for transport service operation to ensure the safe, reliable, adequate, accessible, and acceptable standard. Despite the various structural and systemic transformations in the public passenger transport service in the past, road transport has been well criticized concerning quality. It is important, to note that passengers' care, passengers' safety, bus service availability, timeliness of bus service, cleanliness, attitudes of the staff, and frequency of bus service are the main areas that had to generate criticisms, which may not have been properly communicated electronically (Olorunfemi, 2020). At the micro-level, there is a need to accurately measure the quality of road transport to understand

its variations amongst the various indices all through the service. Among the options available to measure road quality, customer (passenger) satisfaction is widely used in modern research since it has a direct link with the demand for the road transport service and road situation. When passenger satisfaction level is perceived as an alternative to passenger welfare level, an increment in the level of passenger satisfaction will result in a corresponding increase in the level of passenger welfare for individual passengers that experienced the road transport service (Johnson *et al.*, 2001). In Kogi state, virtually all the urban dwellers that are also the passengers of the public transport have various experiences about the situation of road quality and how it has affects their welfare most especially when plying the road. Quality of service can be made clear in several dimensions. In the traditional perspective, quality is measured/ captured based on tangible criteria. Since the judgment of customers was identified to be more pertinent in the quality assessment, the quality was perceived based on the urban dwellers' perspective (Paraskevas, 2001). Furthermore, there seems to a shift from capturing quality measurement from the single indicator to measuring quality on the totality of indicators or dimensions, which may not have properly given enough clues to the policymakers and analysts. To address this issue, there is a need for policymakers to address the assessment of quality from the series or breakdown of quality dimensions (Olorunfemi and Adeniran, 2019). It can be noted that the perception of quality by urban dwellers gives room for identification of pertinent areas of road network attributes that needs urgent attention because of dissatisfaction. Therefore, this study is carried out to address the issues associated with the improvement of road transport quality and aimed to examine the influence of road transport quality on urban dwellers' satisfaction in Kogi state, Nigeria. To achieve this, the road transport attributes and the drivers of satisfaction that should be prioritized for enhancing urban dwellers' satisfaction were identified. The results that emanate from this study will be significant for improving the quality of road transport from urban dwellers' judgment.

Literature review

Conventionally, service quality was determined based on financial performance and other physical performance criteria using single or simplistic

approaches in line with the organizational scope. Paraskevas (2001) observed that with time, service in its entirety became customer-oriented. Amid the recent trend, attributes of service that are required for customer attraction were embedded in the measure of service quality. In the present time, service quality is extensively measured with performance analysis on a multi-dimensional scale from the customer angle (Mosahab *et al.*, 2010). In several related studies, the construct of service quality has been defined concerning user-based assessment to determine the extent to which service is being dished out while measuring the service level (Caruana, 2002). In this study, the satisfaction of road transport quality is measured on a Likert-scale. Urban dwellers, being the customers of the transport services most especially in the urban areas are expected to possess several service attributes from the quality of road transport they use. According to Oliver (1980), a conceptual basis for explaining the satisfaction was provided. This is similar to the approach that an individual's perceived future events, they will establish perceptions concerning the quality of products or services that they intended to purchase. In this study, urban dwellers will establish perceptions concerning the quality of road transport infrastructures. When urban dwellers purchase road transport service, the psychological phenomenon dictates their realized perceptions with their preconceived expectations. Given this, the perceived quality of the services procured is a confirmation of the contradiction of the preconceived expectations. It can be stated that psychological satisfaction predominantly emanates when expectations are met during the use of road transport. When urban dwellers are satisfied with the level of road transport quality, they are likely to be frequent on the road. In a situation where there are no substitutes for a particular road transport network, urban dwellers that are dissatisfied may continue to ply the same infrastructure even if they feel that the quality of that road is good or bad. Nevertheless, when the road transport is constructed by the public sector, the infrastructure can be concessioned to the private stakeholders for management to enhance the long life span of the road infrastructure and increase the welfare of the urban dwellers (Olorunfemi, 2020). Parasuraman *et al.*, (1985) initiated the service quality (SERVQUAL) model or gap model and later several marketing researchers applied the model in their research. Shahin and Samea

(2010) argued that there is no need to get the gap scores from expectation-perception analysis because the perception is well definable and comprehensive to explain the opinion of customers. Virtually, it is more expedient for the researcher to consider only the perception of road transport quality. This study adopts only the perception of urban dwellers on assessing road transport quality. Urban dweller satisfaction is captured by the nature of the road network (Road condition), timely response to the maintenance of the road and sub road infrastructure, provision of transport scheme, communication link between the agency in charge of road transport, and the people. Quality of road transport is captured by the level of safety, comfortability, availability of seat, time delay at the park, overloading and over speeding, condition of the vehicle, compliance with road safety rules and orders, and cost charge per trip. The interconnectivity model revealed in Fig. 1 depicts the indicators or attributes of urban dwellers' satisfaction and road transport quality side-by-side. According to this model, there are four main drivers of urban dwellers' satisfaction in Kogi state, and there are eight main drivers of road transport quality.

Furthermore, this model will be analyzed based on each attribute for specific constructs. Questions were generated based on the attributes of the two constructs, and the relationships will be established on the aggregated and disaggregated levels. The attributes will be identified and analyzed with survey data.

Empirical review

Previous studies on the quality of transport were established based on the SERVQUAL model and quantitative and qualitative research in several countries of the world either developed or developing. The construct of service quality has been appraised majorly based on five different service dimensions which are: reliability, assurance, tangibles, empathy, and responsiveness (RATER) (Ramseook-Munhurrun *et al.*, 2010). Research pieces of evidence revealed that the study on service quality enhances the policymakers to take a vibrant decision that will better the sustainable livelihood. The study of Le-Klahn (2012) conducted in Germany revealed that passengers were mostly satisfied with service reliability, service punctuality, the network connection of service, and frequency of service in public transport. Also, the passengers were dissatisfied with the service and attitude of staff,

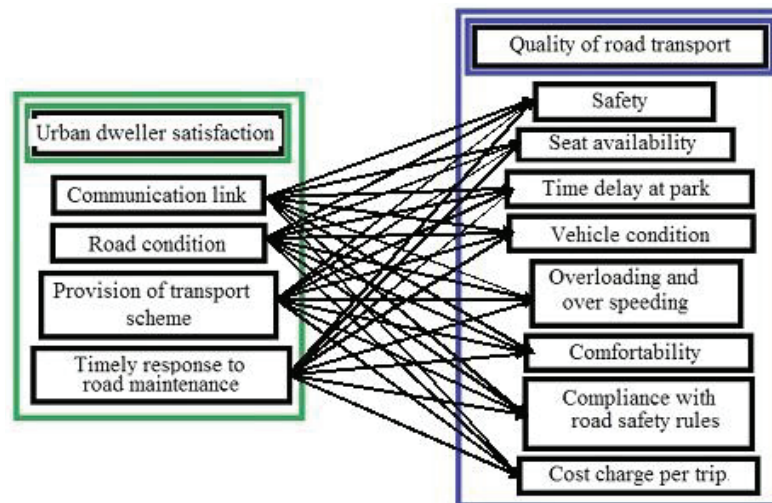


Fig. 1: The interconnectivity model of urban dwellers' satisfaction and road transport quality (Olorunfemi and Adeniran, 2020)

comfort at the bus terminal, and the bus ticket price. The study of Antonucci *et al.*, (2014) conducted in Italy revealed that service punctuality, service regularity, waiting time, the safety of operation, reliability of operations; comforts accrued during service offering, cleanliness, staff professionalism and courtesy were significant factors of passenger satisfaction. The study of Barabino *et al.*, (2012) in Italy identified that cleanliness, On-board security, frequency, bus-reliability are more crucial in determining the level of service quality. The study of Kostakis and Pandelis (2009) in Greece also found that safety, personnel service, bus interior service, time, availability, and the frequency of routes are highly important that influence customer satisfaction in urban transport. In the United States of America, Transportation Research Board (1995) analyzed that some service attributes such as attitude and courtesy of bus drivers, seat availability, bus safety, bus availability, bus accessibility, and justification of bus fares concerning the service rendered. The study of Hossain *et al.*, (2012) in Dhaka found that waiting time and the level of comfort are the main factors that influence passengers' shift from public to private bus transport service. The study of Kamaruddin *et al.*, (2012) in Malaysia found that passengers' expectations of public transport services are largely attributed to safety. In the studies of Kumarage (2004) and Dhingra (2011), it was revealed that some developing cities were faced with the deteriorating quality of public transport services which made passengers shift from considering public transport to private vehicles. The

study of Govender (2014) found that the improvement of perceived service dimensions can result to increase in the demand for public buses and a reduction in the use of private motor cars. The study of Morton *et al.*, (2016) found that perceived convenience, frequency of service, bus availability, bus stability and bus reliability have a significant positive explanation on perceived satisfaction. The studies reviewed above are studies carried out in developed countries, there is a need to review some studies carried out in the developing countries as it mostly associates with this study. The study of Sabir *et al.*, (2014) in Pakistan investigated the quality of transport and found that empathy of bus staff has the strongest positive relationship with customer satisfaction. The study of Nwachukwu (2014) in Nigeria found that comfort, accessibility, adequacy, and bus terminal facilities had the most significant impact on the overall passengers' satisfaction based on the following rank (1st, 2nd, 3rd, and 4th) respectively. Conversely, the attributes identified may be different concerning country norms, social characteristics, and policy directions. Despite the few scholarly articles on urban dwellers' satisfaction in Kogi state, Nigeria, Akeem *et al.*, (2020) investigated public transport service and passengers' satisfaction in Kogi State using a descriptive and binary logit regression model. Their study found that perceived unreliability of transportation service, fare level, and comfortability are significantly related to the perceived satisfaction of passengers. Therefore, while pointing out the research gap, the literature review confirms the pertinence of

improving the quality of road transport. This study is a bit different as it delved into road transport quality based on infrastructures. The current study has been carried out in the nine listed urban centres (Adavi, Okenne, Ankpa, Dekinna, Mopa-Amuro, Kabba/Bunu, Lokoja, Ajaokuta, and Bassa) in Kogi state, Nigeria between 2018 and 2020.

MATERIALS AND METHODS

Kogi State, Nigeria was carved out of Kwara State and Benue State in 1991 and is one of the major States in the Central Region of Nigeria with a population of 3,314,043. Kogi State is located between latitudes $7^{\circ}3'1''N$ - $7^{\circ}52'1''N$ and longitudes $6^{\circ}38'1''E$ - $6^{\circ}42'1''E$. Kogi State consists of twenty-one (21) local government areas and these are Adavi, Ajaokuta, Ankpa, Bassa, Dekina, Ibaji, Idah, Igalamela-Odolu, Ijumu, Kabba/Bunu, Koton-Karfe, Lokoja, Mopa-Muro, Ofu, Ogori/Magongo, Okehi, Okene, Olamaboro, Omala, Yagba East and Yagba West (Fig. 2). The modes of transportation in the state include road and water transportation. For this study, the following urban centres which also the Local Government headquarters in the State have been selected for the study. These are Adavi, Ajaokuta, Okenne, Lokoja, Kabba-Bunu, Mopa-Muro, Ankpa, Bassa and Dekinna. The reasons for choosing these locations are:

- i. They are the principal and major urban centres in the state;
- ii. They are the hub of economic and commercial activities; and
- iii. They generate huge passengers and cargo traffic due to the presence of high commercial activities.

The research relied on both primary and secondary data sources. The primary data sources used to consist of personal observation and questionnaire administration. The secondary data used was the population census figure of Kogi State sourced from the Population Census Commission in Lokoja. To determine the sample size for the research, the population census results of 2006 of the selected urban centres in the study area were determined and put at 1,717,087 (National Population Commission, 2006). This was projected to 2017 at a growth rate of 2.8%; this amount to 2,321,140 from which 1,658 of the household heads were sampled as shown in Table 1.

From Table 1 above, it was noted that 1215 questionnaires were retrieved from the sample

respondents. This implies that a total of 1215 (One thousand, two hundred and fifteen) households head were sampled for the study using a systematic sampling method. The data were presented using descriptive statistics. The variables considered in the study were measured on a five-point Likert scale. Primary data was used to achieve the correlation coefficient which will enhance interconnections between variable constructs.

RESULTS AND DISCUSSIONS

From Table 2, the satisfaction attributes are SA1 (road network status), SA2 (provision of transport scheme), SA3 (timely response to the maintenance of road and sub road infrastructure), and SA4 (communication link between the agencies in charge of road transport and the people in the study area). Also from in Table 2, the quality of service attributes are QA1 (compliance with road safety rules and others), QA2 (cost charge per trip), QA3 (overloading and over-speeding), QA4 (condition of the vehicle), QA5 (comfortability), QA6 (availability of seat), QA7 (time delay at the park), and QA8 (safety).

From the analysis in Table 2, one thousand two hundred and fifteen (1215) respondents reacted successfully to the questionnaires distributed for data analysis and reporting. It was revealed that the satisfaction of urban dwellers regarding the status of the road network has an influence on the transport rate charge per trip at $R: 0.998$ and $p. value: 0.000$. Also, the satisfaction of urban dwellers regarding the provision of transport scheme has an influence on the transport rate charge per trip at $R: 0.905$ and $p. value: 0.000$. The satisfaction of urban dwellers regarding the timely response of road maintenance and sub road infrastructure maintenance has an influence on the transport rate charge per trip at $R: 0.545$ and $p. value: 0.000$. This implies that the level of road condition or status of road condition, provision of transport scheme, and timely response of road maintenance and sub road infrastructure maintenance are crucial determinants when setting the transport rate. According to Bennett and Greenwood (2001); Thagesen (1996), the status of the road network of road condition is the nature of vertical and horizontal alignment of the road surface, the type of road surface, road roughness, road-width and sight distance. This corroborates the study of Berdica *et al.*, (2003) which adopt Paramics model to examine the effect of shutting down a part of the road

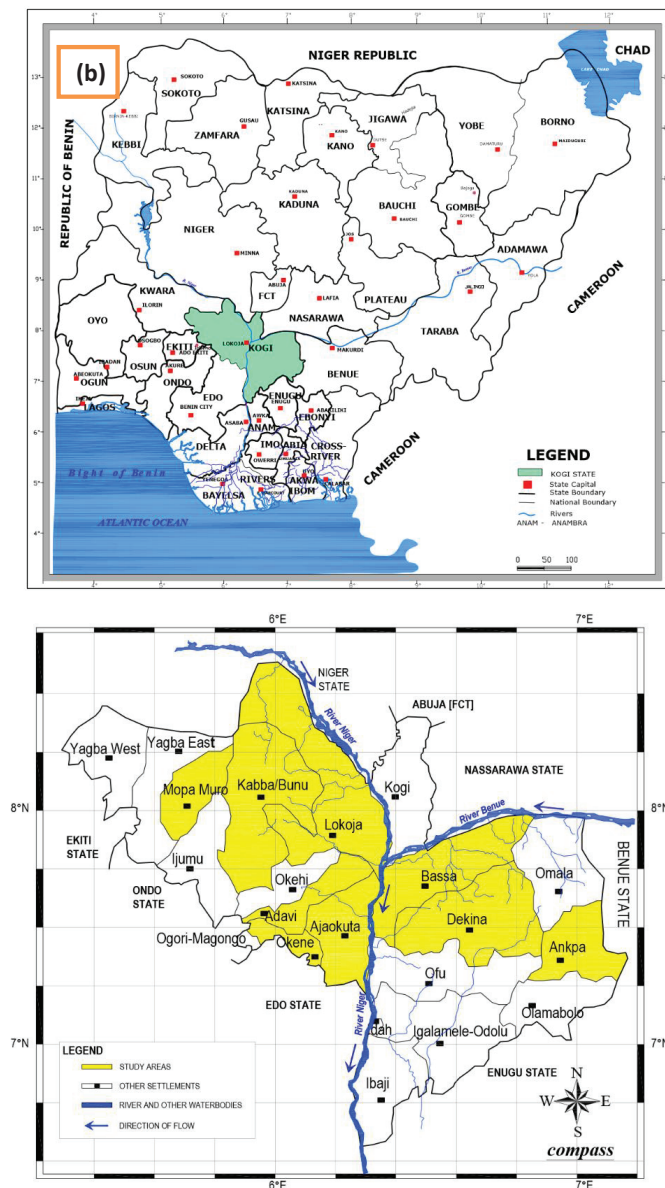


Fig. 2: Geographic location of the study area in Kogi State (a) Geographic location of Kogi State in Nigeria (b) Geographic location Showing Selected Urban Centers (MWUD, 2018)

network in Christchurch, New Zealand for a short term on transport rate of other alternative networks that will experience higher demand of traffic and public increment in the fares of public transport. It is pertinent to note that transport rates are the price (usually monetary) of transportation services that are paid by transport users for moving a passenger or a unit of freight from a specific origin and destination (Adeniran, 2016; Jean-Paul *et al.*, 2006). The effect of road

condition, transport scheme provision, and the response of road maintenance on transport rates alone may not be well identified but will have a significant effect on the transport costs as the poor road condition causes significant loss on the side of the transport service provider. Transport cost covers the monetary measure that a transport provider must incur to make transport service realizable. It may be in the form of fixed costs on infrastructure, and variable costs on operation and

Table1: Projected Population of selected Urban Centers in Kogi State from 2006-2017

S/N	Name of Settlements	X1 2006 Population Figure	X2 2017 Projected Population Figure	X4 Household Heads to be Sampled	X6 0.005% of Household Heads (Sample Size)	X7 Number of Questionnaires Received
1	Adavi	217,219	294,332	10,512	210	150
2.	Okenne	325,623	434,707	15,525	311	205
3	Ankpa	266,176	360,668	12,881	258	200
4	Dekinna	260,968	353,612	12,629	253	195
5	Mopa-Amuro	43,760	59,295	2,117	42	35
6	Kabba/Bunu	144,579	195,905	6,997	140	80
7	Lokoja	196,643	266,451	9,516	190	150
8	Ajaokuta	122,432	165,895	5,925	119	100
9	Bassa	139,687	189,276	6,761	135	100
	Total	1,717,087	2,321,140	82,863	1,658	1,215

X1 - National Population Commission 2006; X2, X3, X4 and X5 - Author's Computation, 2018

Table 2: Correlations between satisfaction and quality of service

		QA1	QA2	QA3	QA4	QA5	QA6	QA7	QA8
SA1	Pearson Correlation	-.129(**)	.998(**)	.411(**)	.998(**)	.545(**)	.006	.003	-.076(**)
	Sig. (2-tailed)	.000	.000	.000	.000	.000	.834	.914	.008
SA2	Pearson Correlation	-.142(**)	.905(**)	.311(**)	.905(**)	.523(**)	.043	.014	-.059(*)
	Sig. (2-tailed)	.000	.000	.000	.000	.000	.137	.626	.041
SA3	Pearson Correlation	-.062(*)	.545(**)	.050	.545(**)	.912(**)	-.019	-.041	-.067(*)
	Sig. (2-tailed)	.030	.000	.079	.000	.000	.510	.150	.020
SA4	Pearson Correlation	.565(**)	-.080(**)	-.089(**)	-.080(**)	-.025	-.101(**)	.318(**)	.119(**)
	Sig. (2-tailed)	.000	.005	.002	.005	.390	.000	.000	.000
	N	1215	1215	1215	1215	1215	1215	1215	1215

** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).

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management, but it is dependent on several factors such as geography (distance and accessibility), energy, infrastructure, administrative barriers, among others. In the case whereby the road is in bad condition as a result of geographical issues, it will result in more energy consumption, which will result in high transport rates on the part of the passengers. It was also revealed in the study of [Berdica et al., \(2003\)](#) that the condition of the road network that warrants repairs and will result into traffic congestion, poor transport schemes, and poor road maintenance because of the poor condition, and if closed down, it will result into congestion and an overall increase in travel time on an alternative route. In the studies of [Bennett and Greenwood \(2001\)](#) and [Ellis and Hine \(1998\)](#), the poor road condition leads to increased fuel and lubricants consumption, high maintenance costs, quick worn-out of vehicle tyres, and increasing labour costs. From the same analysis in [Table 2](#), the

satisfaction of urban dwellers regarding the status of the road network influences the comfort derived from the passengers at R: 0.545 and *p-value*: 0.000. Also, the satisfaction of urban dwellers regarding the provision of transport scheme influences the quality of road transport comfort at R: 0.523 and *p-value*: 0.000. The satisfaction of urban dwellers regarding the timely response of road maintenance and sub road infrastructure maintenance influences the quality of road transport comfort at R: 0.912 and *p-value*: 0.000. The term "comfort" is among the important attributes for measuring the quality of public transport services ([Eboli and Mazzula 2011](#)), it often results to the increasing demand of public transport service as evidenced in China where the quality of comfort in public transport is oftentimes increasing. It is important to note that the bad condition of the road network, poor road maintenance, and the unplanned scheme will have

a significant effect on reducing the level of comfort for urban dwellers. In a situation whereby the vehicle suddenly entered the pothole that is poorly maintained, the passengers will complain. Also, in the case whereby the public transport is not from the park, the comfort of passengers will be undermined as the operators will tradeoff passenger welfare for profit-making. Comfort is among the major social factors that must be measured when determining the adequacy of the effectiveness of public transport policy formulation test before absolute implementation (Xianghao *et al.*, 2016; Sekulicet *al.*, 2013; Castellanos and Fruett, 2014; Zhang *et al.*, 2014; Akhewu, 2010). Furthermore, in the study of Vovsha *et al.*, (2014), it was revealed that in the situation where a passenger has a less than 40 per cent probability of getting a seat, he or she feels uncomfortable. If the seat is not properly positioned especially during galloping, the passenger feels uncomfortable. Clinton *et al.* (2017) are of the view that passengers enjoyed comfort from the transport service providers in the developed because where operations properly scheme such that they operate in accordance to time table whether fully loaded or not. In the study of Litman (2008) it was discovered that in a situation where a bus offers comfortable riding, passengers often perceived that journey time is not up to the actual journey time. This is mostly brought about by good condition of the road network, frequent road maintenance, and planned transport scheme. Furthermore, the satisfaction of urban dwellers regarding the communication link between the agencies in charge of road transport and the people in the study area influences the compliance of road transport operators with road safety rules and regulations at R: 0.565 and *p-value*: 0.000. Globally, the compliance of road transport operators to safety is quite questionable as the high rate of accident is usually recorded. According to Ssewanyana and Niyitegeka (2014), a road traffic accident was estimated to 1.2 million death and 50 million injuries per year, out of which about 85 per cent happen in the developing countries (Derek *et al.*, 2012). From the record, road accident is mostly caused by human error which accounted for about 80-90 per cent of the road fatalities. This includes; over speeding, reckless driving, incompetent driving, driving under the influence of alcohol, among others (Derek *et al.*, 2012). All these can be attributed to the lack of compliance of road transport operators with road safety rules and regulations. This study reveals a need for the effective communication link between the agencies in charge of road transport

operators to enhance safety compliance of road transport operators; this is in agreement with Derek *et al.*, (2012). The public and private transport agencies at different levels are required to massively invest (monetary and effort) in promoting road safety awareness. This will shape the dynamics of road transport operators towards compliance with safety rules and regulations, and thereby making road safety a watchword. Road safety awareness is identified as one of the most crucial ways of persuading road operators to comply with the road safety rules and regulations (Delhomme *et al.*, 2009). The Federal Road Safety Corps (FRSC) only adopts electronic equipment such as walkie-talkies, breath analyzers and speed guns to enforce road safety rules and regulations, and they seem inadequate for collecting electronic data that would be germane for effective communication and the road safety awareness programs. There is need for the use of fundamental management systems such as car tracking device, a navigation device, traffic signal control devices, automatic number plate recognition, speed cameras, security systems, and others that will enhance live data recording and feedback. It will give information about driver profiles, vehicle profiles, parking guidance, weather information, among others for road safety enhancement. From the aggregate perspective, the level of urban dwellers' satisfaction regarding the status of the road network, provision of road transport scheme, timely response to road maintenance and sub road infrastructure, and communication link between the agencies in charge of road transport and the people in the study area mostly influence transport rate charge per trip, the condition of the vehicle, and the quality of road transport comfort. It is pertinent to observe that the condition of the vehicle has a huge significance on the level of comfort being provided.

CONCLUSION

This study examined the influence of road transport quality on urban dwellers' satisfaction in Kogi state, Nigeria. One thousand two hundred and fifteen (1215) respondents reacted successfully to the questionnaires distributed through a systematic sampling method for data analysis and reporting. The variables considered in the study were measured on a five-point Likert scale. Primary data was used to achieve correlation coefficients which enhanced interconnections between variable constructs. It was revealed that the status of the road network has an influence on the transport rate charge per trip at R: 0.998 and *p. value*: 0.000; and

on the comfort derived from the passengers at R: 0.545 and p. value: 0.000. The provision of transport scheme has an influence on the transport rate charge per trip at R: 0.905 and p. value: 0.000; and on the quality of road transport comfort at R: 0.523 and p. value: 0.000. The timely response of road maintenance and sub road infrastructure maintenance has an influence on the transport rate charge per trip at R: 0.545 and p. value: 0.000; and on the quality of road transport comfort at R: 0.912 and p. value: 0.000. The communication link between the agencies in charge of road transport and the people in the study area influences the compliance of road transport operators with road safety rules and regulations at R: 0.565 and p. value: 0.000. Finally, the level of urban dwellers' satisfaction regarding the status of the road network, provision of road transport scheme, timely response to road maintenance and sub road infrastructure, and communication link between the agencies in charge of road transport and the people in the study area mostly influence transport rate charge per trip, the condition of the vehicle, and the quality of road transport comfort. It is pertinent to observe that the condition of the vehicle has great importance on the level of comfort being provided.

AUTHOR CONTRIBUTIONS

S.O. Olorunfemi prepared the manuscript, performed the literature review, compiled the data, and proofread the article. A.O. Adeniran helped in the literature review, prepared the manuscript text, manuscript edition, analyzed the data, and interpreted the data.

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CONFLICT OF INTEREST

The authors declare no potential conflict of interest regarding the publication of this work. Also, the ethical issues including plagiarism, informed consent, misconduct, data fabrication and, or falsification, double publication and, or submission, and redundancy have been completely witnessed by the authors.

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ORIGINAL RESEARCH PAPER

Forming a unique identity derived from cultural values hidden in the collective memories of citizens

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ABSTRACT

BACKGROUND AND OBJECTIVES: The city is not just about appearance. People are present and live with architectural and urban spaces. The changes of Bojnord city after becoming the provincial capital have had many and sometimes destructive effects on the city. The issue of bad identity of cities is not a new one, but how to deal with it, despite the history of the problem, is still unclear. The present research tends to shape the specific identity of Bojnord city based on the cultural values of the city (collective memories and narratives). Therefore, the concept of collective memories of the city has been investigated based on the experiences of residents of Bojnord.

METHODS: The research was carried out using the Grounded Theory method and qualitative paradigm. The participants included 51 people including 32 women and 19 men, residing (as native) in Bojnord. Semi-structured interviews were used to collect data.

FINDINGS: According to the findings, the results of the review of the data were inferred in the 6-core categories, 41-Categories, 55-main Concepts, and 156-point (code) in the Maxqda software. Also, "location tagging (Space labeling)" (46.8percent/73 referrals) and "Native Arts and Local Events" (22.4 percent/35 referrals) were identified as the two main categories with the highest frequency of referenced indications. "The history of the city and its structure" (12.3 percent / 19 referrals) and "wall design" (7.7percent/ 12 referrals) are in the next priorities, respectively.

CONCLUSION: Results indicate the urgent need to identify the particular concept of "collective memories" of each city to revitalize cultural value and the individual and social identity of it, over time.

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INTRODUCTION

In the contemporary era, consideration of values in a period in which "Identity Crisis" has become apparent is considered as an integral part of urban development. Recognizing and identifying the cultural values existing in cities and generalizing them in the form of a particular use and structure that created these values would be a major contributor to the urban development process. Cities with high cultural values may exhibit their culture, history and civilization, and play an important role in improving the image of the city. From a specific point of view of urbanization, the category of identity is, at least for the sake of facilitating the perception of the meaning of the environment, is one of the most important qualitative concepts in human-environmental discussions (Daneshpour, 2004). The idea that cities symbolically relates to values, lifestyles and specific ideas has a long background. The interpretation of the city, the production of new urban imagery and stories, and identification processes, correct our understanding of particular cities (Hobard, 2015). The urban society should be such that citizens in their daily lives achieve unique experiences, like creating artworks. The link between culture and city is not a new idea, as Mumford places the city where the complexity of culture is revealed (Mumford, 1970). Qualitatively, in the contemporary period, the modern city has replaced the old city, and this transformation is a kind of comprehensive Cultural Revolution; whereas, the ancient Iranian city was the center of the historical and ancient Iranian culture and tradition, where the Iranian urban thought has been realized. But the modern city is the origin or source of modern culture or modernity (Fazeli, 2013). In other words, the change in the attitude of man in the world has led to the transformation of identities. The traditional man has searched his identity out of the material world, and a modern man has come to make himself and the world as he wishes. Identity is common in the traditional society and in modern, dispersed and acquired society (Hojjat, 2005). Through the perceptual relation between man and the environment, the environment of meanings and concepts is induced into the minds of men, and thus the values are also reminded and regarded. In the past, Structure inspired the city of Human Scale, Balance and Equivalence and most importantly, spirituality to man, current urban environment, causing insanity,

stress, inconsistency, disproportionality, ugliness and worse of all, is the dominance of materialism and quantity on human life (Naghizadeh, 2002). Since cultural identity is a fundamental feature of human mentality and thought, so this identity and belonging should be reviewed and revised at all levels and ways of improving cultural capacities should be evaluated to improve human quality of life (Rezvani, 2016). Indeed, a city without memory lacks identity, and it also gives the opportunity to grasp and reciprocate the inexhaustible experiences of subsequent generations (Ebrahimi Nezhad and Moghadasian, 2014).

The city of Bojnord, the capital of the North Khorasan province, has undergone significant and quick structural changes, especially in the last decade due to becoming the capital city of the province. Despite the significant development of the city of Bojnord in some aspects, the unpredictable and hasty trend of the city in the worn-out contexts (Especially at the core of the city and the city market), and the lack of attention to the elements forming the mental image of citizens, the collective memories contained in some of these places have been considered Notable. The most important places in the formation of the city's collective memories include: Mirror House Mansion, Besh Qardash complex, Sardar Mofakham Mansion, Sabzeh Meidan complex, Shahid Square, Baba Aman complex, Husseinieh Jajarmi, etc. The lack of proper management of metamorphoses and metamorphosis of urban elements has led to a gradual decline in cultural values. The present study tends to create a "special" identity of the city of Bojnord based on the cultural values of the city Collective Memories (CMs and narratives) to identify the past experiences and achieve identity with the city of Bojnord. Therefore in a few steps, the cultural values of the city were explored with an emphasis on CMs and narratives. Then, with the help of Qualitative Content Analysis and Grounded Theory methods, the concept of CMs is proposed in accordance with the city of Bojnord. Toward this, the main question of the research is that which of the CMs and narratives of the people may be more effective in preserving and enhancing the identity of the city of Bojnord on the basis of cultural values. Therefore, two questions that were intended to provide an adequate response to the original question were considered in the study process. How can cultural values in urban identity be manifested, and how can cultural values help citizens to preserve identity through CMs?

Literature review

The city is not just about appearance. People are present and live with architectural and urban spaces. So they have a sense of belonging to them. In everyday conversations, they talk about them, address them, and even proverbize them in popular culture, creating unique concepts. In this way in the minds of people, a mental image of the city and its components are formed through which the city understands and communicates with it (Massoud and Beygzadeh Shahraki, 2012). Culture has its own values, which these values are represented in ideals, mental images, mental schemas and meanings (Rapoport, 2008). Culture, Structure, and City Identity have an interactive relation with each other; each of which has effect on each other and has implications. City Structure, in addition to the buildings, has a spirit that has emerged from the city's social layers. In addition, since it is a non-verbal communication platform, it induces meanings and concepts to the mind and causes perception of the environment. Indeed, more strength of these meanings in the matter of subject exposure, the decoding and perceptual operations of the environment will be easier. In this regard, referring to Rapoport (2008) point, as the pioneering researcher in the combined study of structure, culture and theology of spaces, in essence, symbols of common social environment and environmental capabilities in the meeting and developing human needs characterize the structural environment as the basis for non-verbal communications - the theoretical literature of research is pre-established. However, since he regards particular importance to behavioral and social values in addition to the implications of the meanings and perceptions (or symbols) of local culture, and acknowledging that the daily lives of urban residents are affected by the process of gaining experience and learning from the urban environment, the discussion of CMs of the city's residents was emphasized by the research. By reviewing the views and studies of researchers in the arena of CMs, the origin, definition, concept and process of analyzing CMs of citizens can be better identified and developed in the present study. Weitz (1972) in his famous book on Aby Warburg's biography, discusses the topic of Social Memory. Warburg pointed out for the first time that familiarity with mythology, literature, history, and social and political life of a particular era are the requirements for the analysis of any artwork. Huyssen (1997) pointed out that Berlin is something like a charter that can concentrate on issues

of urbanization and contemporary architecture, identity and government, memory and forgetfulness. For example, the Berlin Museum is a symbol of collective and general memory, which holds the history of the people (alive or dead). According to Confino (1997), collective memory is the discovery of a common identity that constitutes a social group, a family, or a nation, although its members have different interests and motives. CM creates images of the past for each community. However, a specific time is not chosen from the past to create a difference in society. CM must direct emotions, motivate people to do something; in short, they must become a social-cultural practice. Aby Warburg (1829-1929) used the term "Memory of the Social", although never systematically developed the concept of social memory. French sociologist Halbwachs (1939) was the first who has systematically used the concept of CM. Eyerman (2001) refers to a tragedy of slavery as a CM; a comprehensive reminding that brings people together and prefers them to live in close proximity to one another. Bayliss (2004) explores Ireland's creative planning based on the fundamental role of culture. As part of his work, he quotes from Quinn (1998) that Irish immigrant communities are developing social acts and habits around musical activities; thereby, they create Collective Irish identity. Nowadays, regarding this historical tradition, the music culture of Ireland has flourished at the international level. Yuen (2005) explores the identity of the place in Singapore. He pointed out that the urban landscape is the storage of memories; identity is an important aspect of the planning process, as seek to maintain more buildings to preserve the collective personality and memory of the places. In this situation, the inhabitants of the city, along with memories that are an important part of the collective identity, feel that "this place is theirs" and a great deal of elegance is added to the modern view. In his book with the subject of urban memory (history and forgetting in the modern city), Crinson (2005) pointed to CM as something to be seen from a personalized concept. Lewicka (2008) studied CM in residents of two cities. The existence of an ethnic background is well-known. Misztal (2010) points out in his research that a city with preserved and forgotten memories must be able to adapt to the global community, evolutionary and democratic society. On the subject of CMs, Ryan and Ogilvie (2011) by focusing on values and insights through the photo; Dogan and Sirkeci (2013) by Concluding that when urban

collectable memory is erased from the city, the city's physical and imaginative sources disappears in people's mind; Tighe and Opelt (2016) by doing a research in Asheville, North Carolina on the problem of Collective Memory and Planning as a continuation of the urban heritage renovation; Harolda and Fong (2017) by showing how Collective Memory influences the residential patterns of Jews in Toronto and residential choices and Jein et al., (2017) by concluding that CM is a very selective process in the urban landscap, have conducted various studies which have an effective role in CM theoretical and conceptual advancement. In urban planning, the discussion of CMs has been adopted by the creation and preservation of collective identity, regarding that CMs are the foundation of the "common identity" and the common identity of the reflective CMs. To identify CMs, simply, some researchers concentrate only on a particular topic, for example, only party celebrations and occasions, but it should be noted that these cases alone are not enough. Reviewed studies have shown that the importance of the history of a city is significant in finding common ground among the people of the city. Since the history of the city goes on, the identity of the city is also not fixed. Therefore, in order to avoid differentiation of the future of the city from the past of which, it is necessary to identify the common historical points of the people to be considered in the future planning of the city.

Some of the common points and historical-cultural-social image of a city have a negative side, and others are a positive aspect. CM, which must be preserved, has a selective nature. The people and planners of the city must find out in a constructive intercourse that which memories should be preserved and get objective views. Unrealized CM will be forgotten, and it will not have the cultural-memory transfer values. The current study have been carried out in Bojnord city in 2018-2019. Based on what has been reviewed in theoretical literature, as well as the reviewed researches, it can be said that the experience of the urban environment is a process that is takes place constantly; and the urban experiences that make collectible memories (or individual memories) of cities continue to be the unique identity of a city. It is an identity that differs with the identity of another city. Therefore, the impact of "culture" on the "Structure" of the cities is due to the induction of "cultural values" and its relation with CMs and "identity of the city" was shaped, which will be the main framework of the research. Thus, in the current research, CMs are those memories commonly agreed upon by the public, which reveals the cultural values of a community. Recognizing these memories in cities and displaying them in urban development, in addition to the identification of specific identity areas for the people, play a role in preserving and sustaining the city's identity. CMs occur in urban spaces of the

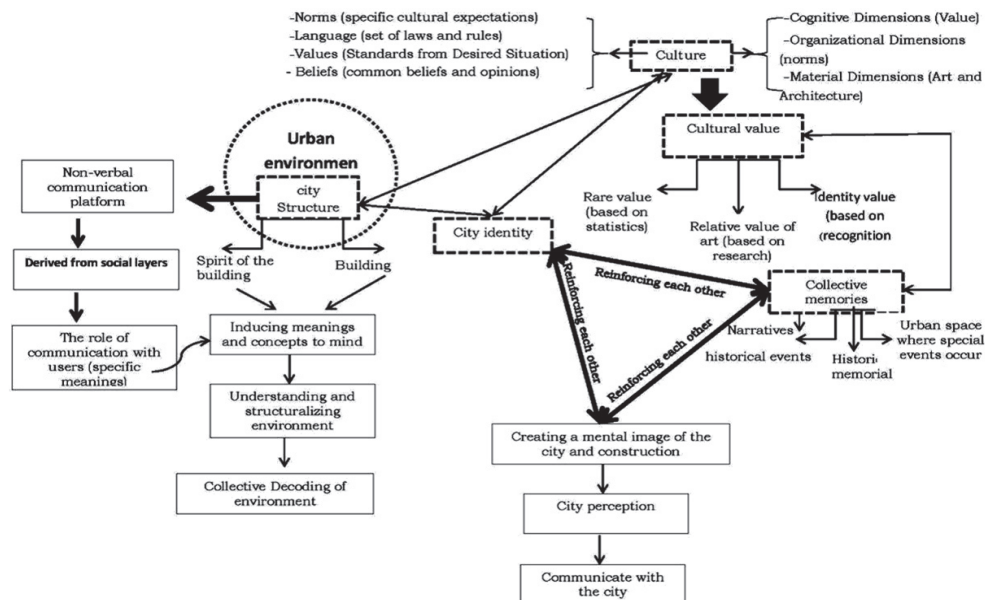


Fig. 1. The Relation between the Main Components of the Research

site of the occurrence of a particular event, historical monuments, narratives, historical events, and mental images of citizens. In the meantime, the mental image of the city bears a more general concept, and memories (individual-collective) and city experience have a direct role in promoting the mental image of citizens. The relation between the main components of the research is presented in Fig. 1.

MATERIALS AND METHODS

The present applied research is a descriptive-analytical research, and has a qualitative approach. The methodology of Grounded theory has been used to analyze the collected data. "Grounded Theory" is a qualitative research methodology applied to investigate the social processes involved in human interactions (Khankeh *et al.*, 2007: 87). While acknowledging that CMs are not realities outside of humans, but in the mind, knowledge and experience and that they are interpreted and defined through interactions between users of places with the human environment.

Grounded theory begins with a theoretical sensitivity defined as the ability of the researcher to understand points and delicacies in the data (Farasat, 2011). For the first time, Glaser and Strauss (1968), introduced the theory of theoretical sensitivity. The methodology of the grounded theory involves understanding the foundations of it under the "concepts" and "categories". "Concepts" are the fundamental units of data analysis in the field theory. The key points of the extracted data are based on analogy and questioning, for which a "code" is determined. Then the identifiers pointing to the common aspect of a phenomenon are read by comparing the category and under the title "Concept." The "categories" in the grounded theory are more abstract than the concepts, and they are at a higher level. The "Category" is formed of the combination of "Concepts." "Categories" provide the foundations for the development of the theory and provide a means to integrate the theory (Rahimnia *et al.*, 2015. Lak, 2014). Grounded Theory is a method for producing a theory that continuously continues from the beginning of the study to the end.

Data Collection Method (data collection tools)

The initial data of the present study were collected using interviews and field observations. Theological and visual data (cognitive plans) for representing experiences and CMs, relates to the qualitative approach of studies.

Writing the text of the interview and defining the appropriate questions have been considered in such a way that all respondents understand the similarity of the question. It is notable that in an interview, a meaningful dialogue was conducted to grasp the context and factors. All interviews were recorded and then written word by word.

Research Process and Data Analysis Tools

Given that the variables of the study are both quantitative and qualitative; the subjective analysis of citizens was the basis of qualitative analysis in order to extract CMs and narratives derived from their potential cultural values. This qualitative study has applied Grounded Theory.

Statistical Population and Sample Size

The statistical society of the research was the population of Bojnord. In this research, a semi-structured interview is used to access the initial data. Selection of people was based on the length of residence and recognition of the past of the city of Bojnord. Acceptability of Data was analyzed with a variety of methods; continuous review, simultaneous analysis of data and feedback to the research, allocation of sufficient time, and the selection of the main information were observed and reviewed for this purpose. In relation to the credibility and reliability of the data, the data of this study was examined with the participants, associates and field experts. Information from the interview was analyzed at the same time using the continuous comparative method. Open coding, axial and selective coding methods were used for this information. Interviews have taken place face-to-face on the neighborhood level and even participant houses (with the permission of the individual, the sound is recorded.). The age range of interviewees is 17-61, with an average age of 33 years.

Scope of Research

The city of Bojnord is the capital city of North Khorasan province, with longitude of 57.19 degrees and latitude of 37.28 degrees. The scope of the research is shown in the Fig. 2.

RESULTS AND DISCUSSIONS

Participants in the study included 51 people (63% women and 37% men) who had the living experience in the city of Bojnord (informed persons). The average

age of the participants in the interview was 33 years. In terms of education, 18% had high school diploma or less, 31% had undergraduate degrees (bachelor's degree and associate degree), and finally, 51% had graduate or PhD degrees. It is notable that 43% of respondents were single and 57% were married. In terms of age, the average living age was 15 years and the average age of residence in Bojnord is 25 years. The grounded theory is explained in the field of research and uses the data obtained from observation and interviewing. After the implementation of interviews in the process of analysis and coding, 55 "Concepts" have been extracted in the open coding stage, which are categorized into 41 "Category" and six "core categories." Core categories are: space markings (specific locations), shell and wall design, structural elements - specific functions, native arts and local Events, historical backgrounds and history

of the city and its structure. A total of 156 referrals are referenced in line-through interviews and qualitative analysis of mental image plans. All the extracted factors are first considered as code. Then, regarding the concept of each code, they are categorized in the same concept. In this way, the main categories of research are formed. The basis for categorizing these codes is the degree of similarity of different codes. In Table 1, the core categories, concepts and signs are presented. 156 codes were identified in reference software of Maxqda5. In this regard, taking into account the frequency of a total of 790 codes, extracted with frequency. The process of monitoring the interviews is shown in Fig. 3.

The most important signs taken from the perspective of Bojnord interviewees (shown in table 1) are: Mofakham Mirror House (N=60), Bash Qarshash Promenade (N=36), the word or term of Bijan Yord

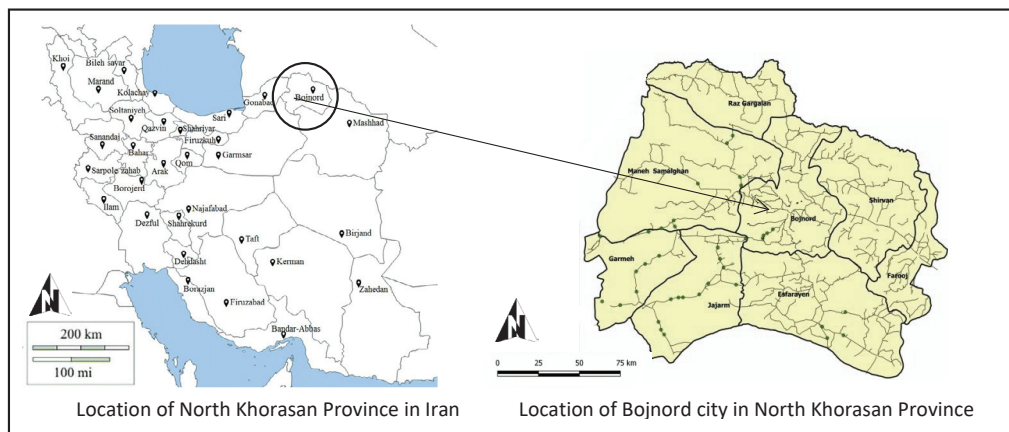


Fig. 2. Location of the city of Bojnord in the country divisions and North Khorasan Province

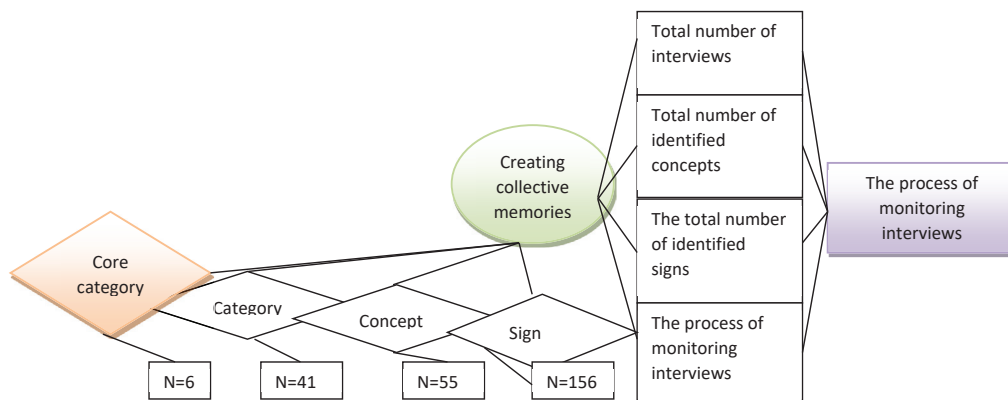


Fig. 3. Interview Monitoring Process (Process Identification of CM in Bojnord)

Table 1. Frequency of extracted codes

Core category	Frequency of codes (symbols)	Relative portion (%)
Space labeling (specific place)	73	46.8
Shell and wall design	12	7.7
Specific functional – structural elements	10	6.4
Native Arts and Local Events	35	22.4
Historical cultures and spatial dependencies	7	4.5
The history of the city and its structure	19	12.2
Total	156	100.0

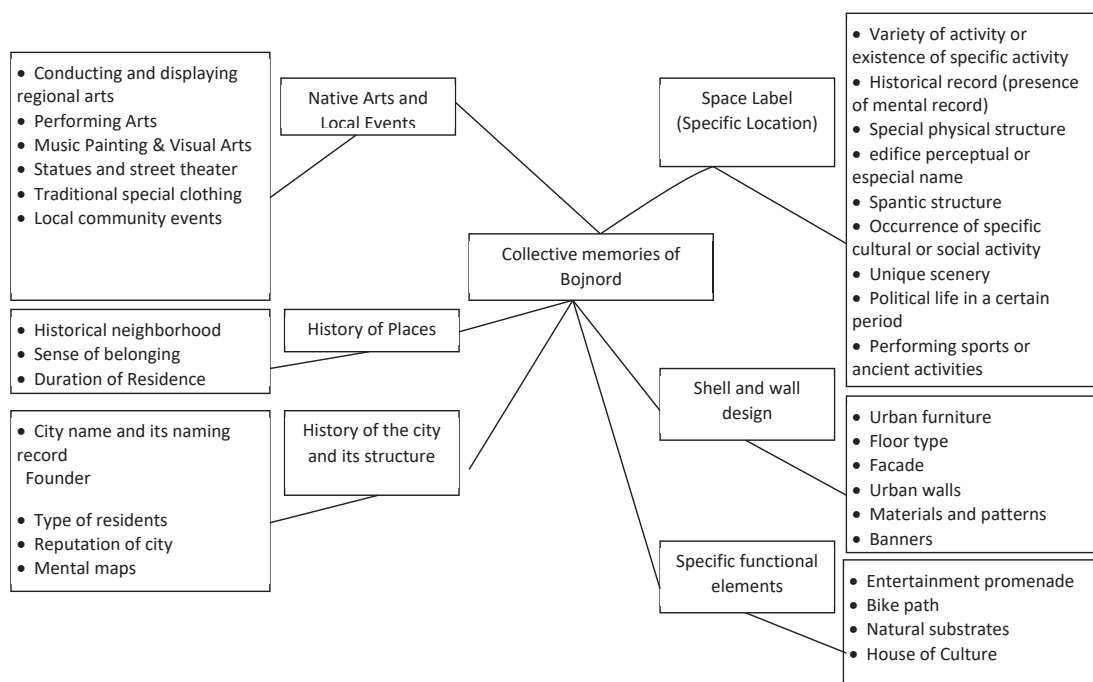


Fig. 4. Core Categories and Main Category in the re-production of the CM concept in Bojnord

(N=34), Sardar Mofakham Mansion (N=29), Sabzeh Meydan Complex (N=26), the phenomenon of new and old views alongside each other (as the citizens, in view of the ever-increasing changes in the development of the city of Bojnord, see these in their minds, and sometimes use them in addresses) (N=24), the phenomenon of the province of North Khorasan (the centrality of the city of Bojnord in 2005) as a turning point in the minds of citizens, the factor that has been mentioned as the source of urban development and consequently the increase of urban facilities (N=24), Shahid Square (city center) (N=23), the sense of belonging to the city and the importance of living in it (N=23)⁶, Baba Aman complex of Bojnord (21N =), the term of Bijangard (N=17), new changes in the city in terms of urban furniture and sidewalks (N=16), local

dance (N=16), local music - traditional and Maghami (N=15), Hosseiniyeh Jajarmi (N=14) and Masoumzadeh Hill (N=14). Among the Core categories, the labeling of space (specific place) is 46.8 percent, and "Native Arts and Local Events" with relative frequency of 22.4%, respectively, are the most referenced and important.

Consequently, the conceptual model and the theoretical framework of the CMs in Bojnord (Fig. 4 and Fig 5) can be inferred. The location of defined Key signs (the ones in the city) is shown in fig. 6 however, the key signes Besh Qardash and Baba Aman, are two Park Complexes, located at the exit of the city towards Mashhad and Tehran. Therefore, planning for cultural values based on the CMs of the citizens, and according to the findings of the present study, should be based on 6 identified Core categories. In fact, Bojnord residents

Forming a unique city identity hidden in the collective memories

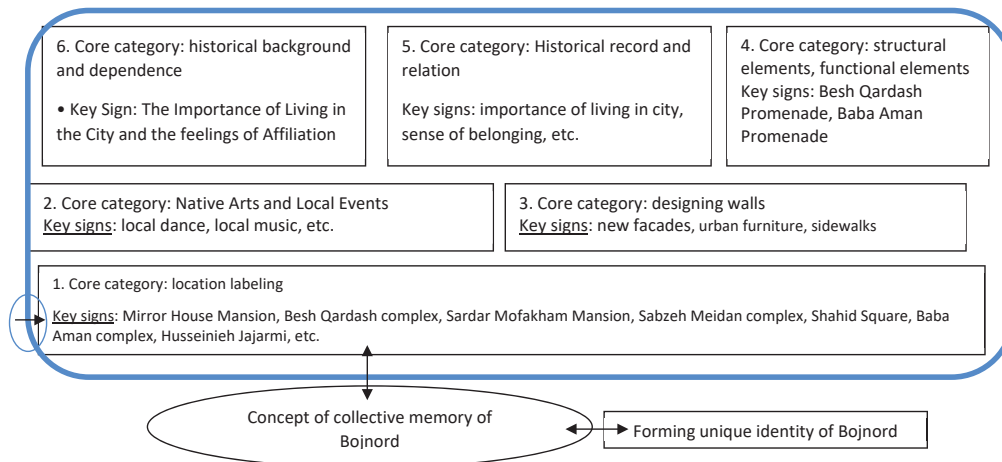


Fig. 5. The most important Core categories identified for extracting the concept of CMs in the city of Bojnord



Fig. 6. The location of defined Key signs in Bojnord city

have most of their memories from these identified categories. Therefore, these categories should have the largest share in the cultural planning of the city. In this case, the unique identity of the city of Bojnord will be formed by emphasizing the CMs of the citizens. Compared to other studies reviewed in the paper, none of them applied the role of collective memory in urban management and planning. However, the reviewed articles are considered important in the theoretical and conceptual development of collective memories (Weitz (1972); Hussen (1997); Coinfo (1997); Lewicka (2008); Misztal (2010)).

CONCLUSION

“Memory”, as an explicit and semantic memory, is one of the most important elements in preserving the experiences of the past generation and the memory of cities. Essentially, a city without memory is a city without identity and CMs have a great contribution to the transfer of cultural values governing society and its continuity. Regarding the “shared” nature of CMs between the inhabitants of a city, these elements can be identified as a symbol of the city’s identity, which is a symbol of the commonalities of a group of human beings. In present study, attempts

were made to identify signs and examples of CMs in Bojnord using 51 semi-structured interviews. In the study process, 156 codes were identified in the referenced Maxqda software. It is noteworthy that some identified codes have several frequencies. In this regard, 790 codes were extracted taking into account the frequency. Among identified codes, exploration and re-production of core concepts, core categories, and main categories were considered based on research background and subject. 6 core categories were identified; in the meantime, core category (in the unstructured category) with 46.8%, the category of the Native Arts and Local Events (in non-structured categories) with 22.4% of the most referenced code have been included in there. Finally, the conceptual model of the CMs in Bojnord can be inferred which will play a significant role in forming the Unique identity the city. Establishing a tangible relation, and consequently a tangible interrelation of society and the city, Potential Identity Symbols can transform a city into the minds of citizens, apart from the monotony of life, into symbols with a dynamic identity. The identity elements of a city, if they are in the process of adapting to the imaginary form, acquired acquisition habits, memory, recollection and successful experience, will have a stronger function in structuring the city's objective and subjective structure. At the same time, if Structure represents the values of the identity of a community, it will also be more successful for the transfer of the city's culture and its cultural effects from one generation to its subsequent generation (the identity element will be identified to humans). The culture of a city is a matter of great concern, to the point where they regard the importance of culture for a community with an allegory such as Memory for the individual. In other words, these cultures are essentially forms of human and social life. From this perspective, identity as a social concept is considered a social structure that is heavily influenced by the culture of society. Culture as the field of all values of the society, the factor of the relation between the different generations experiencing the city and, in other words, the factor that identifies the generations with different experiences of the city, historical periods and in general Memory of the cities. Meanwhile, if the current identity crisis of cities, which is in conflict with the identity of the traditional and modern world, can establish the identity of the cultural values that govern the community, in fact, we keep the memory of the cities, that is to say, preservation and shaping to the unique and native identity of a city which has

been discussed in this research in the codification of the theoretical model and the concept of CMs of citizens in the city of Bojnord. The application of the explanatory model in the management and planning of Bojnord city is accompanied by the following recommendations:

1. Urban planners can design urban development plans more purposefully, considering the variables that are more important such as the elements which remain in the minds of people; if they are regarded in the designs, a stronger structure of the city is formed in the minds of residents. A structure that in some of its development centers represents the emergence of CMs and incidental lives.
2. Regarding the knowledge of the elements and signs of CMs in Bojnord (the findings), case studies may be implemented about the capacity of the general arenas of the city to produce CMs.
3. Regarding the identification of 156 effective signs in the production of CMs in the city of Bojnord, It would be noteworthy if signs are quantitatively prioritized with multi-criteria assessment techniques.
4. Organizing special events and occasions, exhibitions of indigenous products and crafts.

Ultimately, any management, planning and urban design of the city of Bojnord should emphasize on the identity, memory and meaning of urban environments. Improving the quality of the spaces in Bojnord should be done in order to balance the structure between the elements of structural and non-structural identity in the creation of CM of Bojnord. In this case, the set of urban spaces of Bojnord will have unique features; by confronting the values and concepts that exist in other places. This brings a unique identity to the city of Bojnord.

AUTHOR CONTRIBUTIONS

This article is extracted from a PHD course in Tabriz Islamic Art University. Motalbi, Gh. and Sedaghati, A., designed the model and the computational framework and analyzed the data. Also they carried out the implementation. A.S. performed the calculations and wrote the manuscript with input from all authors. GH.M. and A.S. conceived the study and were in charge of overall direction and planning.

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CONFLICT OF INTREST

The authors declare that this study has no conflict of interests in the publication of this manuscript. So also, the ethical issues were observed and informed consent of the participants were sought with plagiarism check.

ABBREVIATION

CMs	collective memories
CM	collective memory

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ORIGINAL RESEARCH PAPER

Impact of rainfall on natural attenuation of diesel and waste oil within urban base transceiver stations

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ABSTRACT

BACKGROUND AND OBJECTIVES: *Very low grid power penetration in some urban areas has led to telecoms companies investing massively in the deployment of diesel generators (DGs). These deployments have led to diesel and waste oil spill at base transceiver station (BTS) sites during maintenance cycles, impacting the environment and human activities. The objective of this study is to evaluate the impact of different rainfall intensities on the amount of waste oil and diesel leached or retained in the soil during natural attenuation.

METHODS: The soil at base transceiver station was analyzed using response surface methodology (RSM). The experiment was carried out following the design of experiment approach with a 3³ factorial. Three factors include contaminant volume, rainfall intensity, and soil depth on which the two response variables (leached and retained) were utilized.

FINDINGS: It was observed that rainfall intensities at 5mm/hr, 7.25, 9, and 10mm/hr has a significant impact on the amount of waste oil leached (1611.63mg/l) and retained (15888.9%) in the soil, though the amount of oil leached is inversely proportional to the amount retained as affected by different rainfall intensities considered in this work. Additionally, it was observed that rainfall intensity increases as the amount of oil leached decreases at higher soil depth while the amount of oil retained increases at lower soil depth. However, the significance of the impact of the different rainfall intensities is dependent on the soil depth.

CONCLUSION: The regression coefficient was found to be 72 % for waste oil retained and 67 % for the leached amount, hence the quadratic model developed in this study, demonstrated a higher accuracy for %retained rather than the amount of oil leached. However, this implies that the model is reliable, dependable, effective and accurate and thus recommended for use.

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INTRODUCTION

Telecoms companies have invested a lot in providing power to Base Transceiver Stations (BTS) sites to serve growing customers (Olukolajo *et al.*, 2013; Patti and Siana, 2016). This necessitated the deployment of diesel generators to BTS sites for the provision of suitable power for the equipment (Roy, 2008). This is more so due to the epileptic nature of the National grid and sometimes non-availability of power at some remote locations. In addition to Diesel Generators, Telecommunication companies have invested massively on alternative energy solutions by the deployment of solar panels, hybrid solutions, and direct current diesel generators (Turletti *et al.*, 1999; Martin, 2006). Diesel engines represent one of the technological basements of today's economy. Their usage is so diverse and widespread that their direct or indirect contribution is included in almost every product or service. However, the utilization of diesel engines results also in undesired impacts, particularly because their widespread usage takes on disturbing dimensions. Although they show a higher level of fuel use efficiency compared to the gasoline engines, the diesel exhaust gases contain significantly higher concentrations of the most dangerous substances like the particulates (Godwin and Bassey, 2009; Satish, 2012) which have been the scientifically proven cause of some of the most severe diseases and may even lead to premature death (Shivendra and Hardik, 2017). The use of DGs in powering BTS has its drawbacks when compared to alternative energy, which includes but not limited to diesel and oil spillage especially during maintenance cycles. The process of utilizing these products associated with human mismanagement leads to the spill of these products in the environment in and around many BTS sites (Aderoju *et al.*, 2014). Unfortunately, most of the BTS sites are close to human habitation/infrastructure (NCC 2014). These products tend to impact negatively into surroundings affecting water, soil, and atmospheric air (Joo *et al.*, 2008). Similarly, the use of diesel and engine oil for maintenance and power of DGs has been established to impact negatively on the environment once they are mismanaged; groundwater contamination, disease conditions, soil deterioration, and air quality alterations are possible problems that are likely to be associated with the mismanagement of these products at BTS sites (Bello, 2010). These liquids that are generated

during DG maintenance, site diesel transportation, and refueling, have been proven to contain harmful and toxic compounds or substances such as Polychlorinated Biphenyls (PCBs), benzene, arsenic, Polycyclic Aromatic Hydrocarbons (PAHs), lead, zinc, cadmium and other substances that adversely impact soil, groundwater, and environment. At BTS sites, the effect of temperature, and effective remediation mechanisms that could be adopted to reduce, remediate and possibly eliminate impact on the environment as much as possible and avoid litigations and fines. Although, the chemical composition of waste engine oil depends on many factors. These factors include the process of refining the crude oil, additives in the oil, the amount of time the oil worked in the engine, type of crude oil, etc. while Diesel in soil has been known to contain PAHs and PCBs. Polycyclic Aromatic Hydrocarbons (PAHs) are persistent organic pollutants (POPs) that are resistant to degradation and remain in the environment for longer periods (Mudge and Pereira, 1999; Venkata *et al.*, 2009; Berkhout and Hertin, 2012) and have the potential to cause adverse environmental effects (Kordybach, 1999). PAHs have unique stable structures to persist in the environment (Sugiura *et al.*, 1997) and highly hydrophobic, so these have a strong attraction to soil particles (Sung *et al.*, 2001). Also, used engine oil and diesel which are often discharged indiscriminately on the soil have been attributed to transport downwards and pollute the underground water, including high chances of migrating even into fish ponds, as has been observed. However, biodegradation rates are highest for the saturates, followed by the light aromatics, with high-molecular-weight aromatics and polar compounds exhibiting extremely low rates of degradation (Cooney and Silver, 1985; Reisinger *et al.*, 1995; Rowland *et al.*, 2000; IMO, 2004).

It is therefore imperative to ascertain the impact of the leaching rates of diesel and waste engine oil mismanagement at these BTS sites and as well determine the level of impact of such spill on the environment vis-à-vis different soil types concerning the Niger Delta and to ascertain the impact of weather (Rainy and dry seasons) on the leaching rates of spilled diesel and waste engine oil. This helps the Telecoms companies to determine the extent to which environmental deterioration. This study seeks to investigate the impact of rainfall intensity on diesel and engine oil leaching in soil from Base Transceiver

Stations. The current study has been carried out in Bayelsa State in 2019.

MATERIALS AND METHODS

Description of the study area

Bayelsa is a state in southern Nigeria in the core Niger Delta region, between Delta State and Rivers State. Its capital is Yenagoa, the Latitude and longitude coordinates are 4.664030, 6.036987. The main language spoken is Ijaw with dialects such as Kolukuma, Mein, Bomu, Nembe, Epie-Atisa, and Ogbia. Like the rest of Nigeria, English is the official language. The state was formed in 1996 from part of Rivers State and is thus one of the newest states of the Nigerian federation. Bayelsa has a riverine and estuarine setting. Many communities are almost (and in some cases) surrounded by water, making them inaccessible by road. The state is home to the Edumanom Forest Reserve, in June 2008 the last known site for chimpanzees in the Niger Delta. Rainfall in Bayelsa State varies in quantity from one area to another. The state experiences the equatorial type of climate in the southern the most part and tropical rain towards the northern parts. Rain occurs generally every month of the year with a heavy downpour. The state experiences high rainfall but

this decreases from south to north. Akassa town in the state has the highest rainfall record in Nigeria. The climate is tropical i.e. wet and the dry season. The amount of rainfall is adequate for all-year-round crop production. The wet season is not less than 340 days. The mean monthly temperature is in the range are of 25°C to 31°C. The mean maximum monthly temperatures range from 26°C to 31°C. The mean annual temperature is uniform for the entire Bayelsa State. The hottest months are from December to April. The difference between the wet season and dry season on temperatures is about 2°C at the most. The relative humidity is high in the state throughout the year and decreases slightly in the dry season. Like any other state in the Niger Delta, the vegetation of Bayelsa State is composed of four ecological logical zones. These include coastal barrier island forests, mangrove forests, freshwater swamp e.g. forests, and lowland rain forests. These different or vegetation types are associated with the various soil units in the area, and they constitute part of the complex Niger Delta ecosystems. Parts of the freshwater swamp forests in the state constitute the home of several threatened and even endangered for plant and animal species. There are coastal barrier highland forests and mangrove forests. Coastal barrier highland forest vegetation is restricted to the narrow ridges along

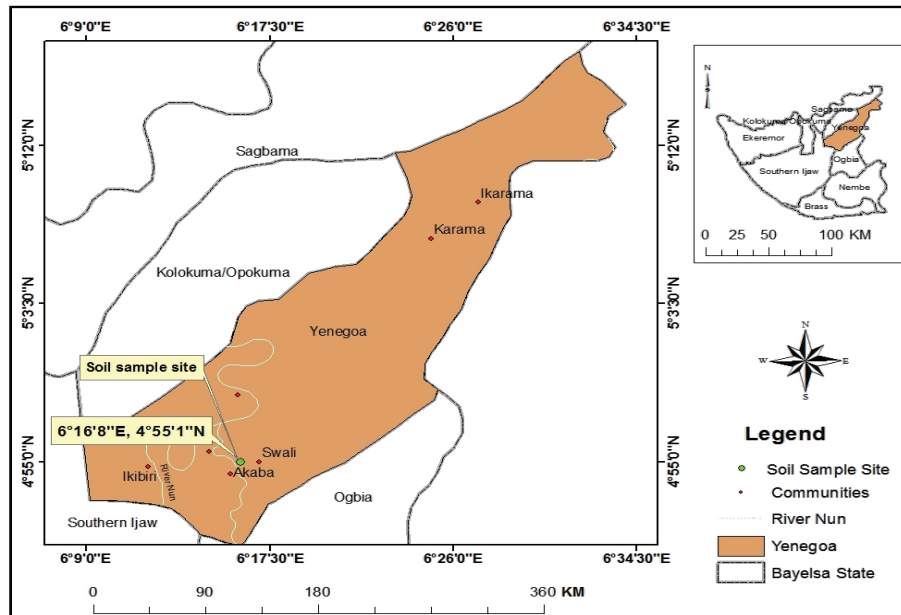


Fig. 1. Map of study area showing the BTS sites

Table 1. Physical characteristics of the soil at different sites

BTS site	Coordinates	Clay	Silt	Sand	Gravel
Oloibiri	4.6748° N, 6.3133° E				
Amasoma	4.9731° N, 6.1090° E				
Ogbia	4.6901° N, 6.3213° E				
Otuoke	4.7944° N, 6.3146° E				
Agudama	5.0167° N, 6.2667° E				

*Dark blue = clay, *Light green = Silt, *Blue = sand

Table 2. Experimental design and level of independent process variables

Independent variables	Unit	Factors	Coded level		
			-1	0	+1
Contaminant volume	ml	A	50	200	350
Rainfall intensity	mm/hr	B	5	7.5	10
Soil depth	cm	C	30	60	90

the coast. This vegetation belt is characterized by low salinity-tolerant freshwater plants. Sometimes of the *Avicinia species* of mangroves prevail in this vegetation. The study area is shown in Fig. 1.

The soil characteristics show that the locations are dominated by silt and sand respectively.

Design of experiment (DOE)

The experimental design was set up using DOE software Version 11.0.1. using 3^3 factorials. The variables and their range are given in Table 1. The variables are coded as contaminant volume (A), rainfall intensity (B), and soil depth (C) as designed in the study. Although, each factor in Central Composite Design (Ahmadi *et al.*, 2005) has five stages and grouped into three design points, which are identified as two stages of factorial points, well-defined as 1 and -1, (axial points), and a (center point) defined as 0 as shown in Table 2. However, the center points are primarily repetitive trial arrays closer to the center of factor space to endorse the best prediction potential. In the present study, there are 27 experimental runs (Table 3).

Experimental procedure

Sample collection

A galvanized steel mesocosm was constructed to collect soil undisturbed (ASTM 2005). Three sets of 300mm, 600mm and 900mm height diameter galvanized steel pipes were constructed to produce the mesocosm used in this study. Before the collection of the soil sample in any of the base transceiver station sites, the topsoil was cleared to a reasonable

depth. The galvanized steel mesocosm, hammered with the aid of a fabricated auger rig, was used to directly collect undisturbed soil samples. 5 samples each were obtained from the study location, 1 sample from each site within the state. The collected soil samples were further analyzed in the laboratory to determine the predominant soil type at the BTS within the study area where the samples were obtained. The soil samples were analyzed and predominant soil types were obtained utilizing grain size analysis using the hydrometer method. The waste engine oil was collected during the frequent maintenance of the diesel generators used to power the base transceiver station sites (BTS). The waste engine oil sample was collected using plastic bottles that were prepared by initial rinsing with the waste engine oil to be collected and then filled almost completely, while the diesel sample used for this contamination experiment was obtained from a regular fuel station. Both the waste engine oil and diesel samples were properly labeled and immediately transported to the laboratory under room temperature. The experiment followed a full factorial design of 3^n , where 'n' is the number of variables. Three variables were considered, namely: soil depth within the range of 30cm – 90cm, contaminant volume 50 – 350ml, and rainfall intensity 5 – 10mm/hr. Waste engine oil and diesel were the contaminants utilized separately and in their combination. Hence, 33 resulted in twenty-seven (27) experimental runs. The selected rainfall intensity values were chosen to replicate rainfall patterns recorded in each of the considered Niger Delta states, as was obtained from the Nigerian Meteorological

Agency, NIMET. The following materials were used, (1) galvanized steel mesocosm, (2) auger rig, (3) measuring cylinders, (4) mini lysimeter, (5) rainfall simulator, (6) gas chromatography, (7) plumbing fittings (like union, valves, adaptors, pipes, elbows), (8) calibrated buckets, and (10) stopwatch.

Rainfall simulator set-up

The rainfall simulator was constructed to imitate the rainfall pattern of Bayelsa state, using the data obtained from the Nigerian Meteorological Agency (NIMET). The obtained rainfall data were used in calibrating the rainfall simulator to produce 5mm/hr, 7.5mm/hr, and 10mm/hr rainfall intensities, for different volumes of spilled diesel, used engine oil and a combination of both. The rain simulator was made of a rubber tank of 1000L capacity constructed on a squared shape 75mm galvanized steel tank stand, as seen in Plate 3.6. Also, a 37.5mm horsepower surface water pump was utilized for continuous refilling of the tank using 37.5 inches PVC pipe, in conjunction with some plumbing fittings like union, valves, adaptors, pipes, elbows; to hold firmly. To create avenues for the simulated rainfall on soil samples, three showerheads were also connected using 37.5 to 12.5" reducers, 12.5 inches PVC pipes, union, valves, elbow, adaptors, and other plumbing pipe fittings. The showerheads were mounted on a 25mm diameter galvanized steel pipe welded to a 20mm steel base plate to ensure the effective stability of the shower headstands. Three transparent 5L plastic calibrated buckets were provided to collect the water during the simulation. One of the 1000L and 2000L measuring plastic cylinders were also provided to measure the amount of rainfall. A stopwatch was provided to measure the duration of rainfall when the valves were opened for water inflow. Therefore, the intensity of the simulated rainfall was obtained as the height of rainfall collected within a 150mm diameter pipe, per hour of rainfall.

Mesocosm set-up for sample collection

Some galvanized steel mesocosms were constructed to collect soil samples in an undisturbed condition. Three sets of 300mm, 600mm and 900mm diameter of galvanized steel pipes were constructed to produce a mesocosm. The mesocosms were used to directly collect soil samples using a fabricated auger rig undisturbed soil collector. Upon collection from

the field, the mesocosms containing the soil samples were carefully transported to the laboratory for contamination and rainfall simulation experiments. Clips were also produced to hold the mesocosms in place on a table while being contaminated and rainfall patterns simulated. The sets of 600mm diameter holes were constructed to install the 300/600 and 900mm high mesocosms that have the same diameter. The bottoms of the mesocosms were protected with a net to prevent erosion and sieve the washout with the aid of a fabricated galvanized steel clips. Simulated rainfall at various intensities (5mm/hr, 7.5mm/hr, 10mm/hr) and volume of contaminants (50ml, 200ml, 350ml) were introduced to the undisturbed soil in the mesocosm. Leachates were collected using plastic containers placed at the bottom of the elevated steel mesocosms.

Total Petroleum Hydrocarbon (TPH)

The main objective of the TPH test is to determine the rate of penetration of the contaminants into the soil at BTS sites and to assess the rate of pollution of petroleum products in the soil at BTS sites (Chaillan *et al.*, 2006). To determine the actual effect and the rate of pollution of these petroleum products, we have to look at water (H₂O) and soil since it has to do with the environment. The presence of used engine oil and diesel in water can be easily identified due to density disposition. However, simple chemical analysis is used as a mode of separation by using an extraction solvent to determine its hydrocarbon content. The use of this extraction solvent is to digest hydrocarbon content and aid the separation process. Hexane was used as the extraction solvent.

Procedure for water hydrocarbon extraction using hexane as a hydrocarbon solvent

The following materials were used; (1) gas chromatography (2) separation funnel (3) beaker (4) measuring cylinder of 100ml and 50ml (5) bottle (6) beaker stand and (7) masking tape. The water contaminant samples were gotten from different depths within the study location. The contaminant samples were poured into different plastic rubbers and labeled for proper identification. The H₂O samples were then transported to the laboratory in Rivers state university, Nigeria. A sample labeled OBS (H₂O: leachates) and hydrocarbon solvent (Hexane) were measured at a ratio of 2:1. The samples were mixed in

a plastic bottle and agitated aggressively for about 10 - 30 minutes. The mixture was then placed on a clamp stand (H_2O + Hexane) after pouring into a separation funnel to allow the mixture to occupy their space based on their density. This process is also known as the stage of decantation. The Mixture was then left in the separation funnel. Undisturbed for about 20 minutes to enable the different layers to be formed properly. The Hexane digested the contaminant and occupied the upper layer while the H_2O which has a higher density occupied the lower layer. The separation funnel was released gradually and H_2O which occupied the lower layer was discarded. The second stage of the separation process was done, by adding 25ml of hexane (C_6H_{14}) to the new sample. This mixture was then agitated aggressively for about 10 minutes and poured into the separation funnel. The Mixture was left undisturbed for 10 minutes. The separation funnel was released gradually and the remaining water content was discarded appropriately. The sample was then poured into the receiver carefully and labeled according to the identification

mode of the sample. The sample in the receiver was then introduced into the gas chromatography. The above procedure was done respectively for each of the contaminant samples collected at different depths and areas.

Procedure for soil hydrocarbon extraction water content determination by oven dry method

A clean, non-corrosive dry dish was obtained and its weight was determined. Using a balance (with minimum sensitivity to weight the samples to an accuracy of 0.04% of the weight of soil taken. This comes to a sensitivity of 0.01g. The required quantity of a representative undisturbed soil sample was taken and placed on the container. The weight of the container and the wet soil were determined. The container with wet soil was placed in the oven with its lid removed for 24 hours maintaining a temperature of $105^\circ C$ (slightly > the boiling point of water). The container now containing dry soil was then cooled in a desecrator with the lid closed. The weight of dry soil with the container and lid was determined. The oven-

Table 3. Showing the factor combinations and response variables

Run	A: Contaminant Volume (ml)	B: Rainfall Intensity (mm/hr)	C: Soil Depth (cm)	Retained %	Leached (mg/l)
1	50	5	30	4323.5	5134.8
2	200	5	30	5757.12	6233.24
3	350	5	30	6997.67	1000.55
4	50	7.5	30	3876.58	4129.46
5	200	7.5	30	4263.63	4920.93
6	350	7.5	30	4286.54	5011.82
7	50	10	30	2566.2	4411.9
8	200	10	30	4100.95	5348.81
9	350	10	30	5400.4	6258.93
10	50	5	60	3611.11	9899.03
11	200	5	60	3000.93	9898.57
12	350	5	60	1948.55	1295.36
13	50	7.5	60	4073.51	4351.02
14	200	7.5	60	4062.42	6239.91
15	350	7.5	60	3424.62	9459.96
16	50	10	60	10241	3366.1
17	200	10	60	3182.42	4718.02
18	350	10	60	3133.51	5499.92
19	50	5	90	9840.72	1077.77
20	200	5	90	9503.42	1211.91
21	350	5	90	9414.47	1241.97
22	50	7.5	90	9361.51	1365.76
23	200	7.5	90	9214.53	1444.96
24	350	7.5	90	9161.53	1492.45
25	50	10	90	8776.96	1340.34
26	200	10	90	8999.99	1545.03
27	350	10	90	15888.9	1611.63

drying temperature of 105°C is suitable for most of the soils. A temperature higher than that should not be used as it breaks the crystal structure of the soil and caused evaporation of structural water. For soils containing other minerals, there is losing bound water of hydration (adsorbed water) which gets evaporated at 110°C, hence a lower temperature of 80°C should not be used for oven drying of such soils.

RESULTS AND DISCUSSION

The following results were obtained for the amount of waste oil and diesel retained and leached in the soil after the 27 experimental runs carried during the study period (Table 3).

The model F-value of 5.03 implies the model is significant. There is only a 0.21% chance that an F-value this large could occur due to noise. P-values < 0.0500 indicate model terms are significant. In

this case C, C² are significant model terms. Values greater than 0.1000 indicate the model terms are not significant as shown in Table 4. If there are many insignificant model terms (not counting those required to support hierarchy), model reduction may improve the model. Although, the predicted R² of 0.1947 is not as close to the adjusted R² of 0.5827 as one might normally expect; i.e. the difference is more than 0.2. This may indicate a large block effect or a possible problem with your model and/or data. Things to consider are model reduction, response transformation, outliers, etc. All empirical models should be tested by doing confirmation runs. Model Precision measures the signal to noise ratio. A ratio greater than 4 is desirable. The ratio of 6.837 indicates an adequate signal. This model can be used to navigate the design space. See the coefficients in terms of the coded factors in Table 5.

Table 4. ANOVA for quadratic model, response 1: %retained (R² = 0.7272)

Source	SS*	Df**	MS***	F-value	p-value	Remarks
Model	2.129E+08	9	2.365E+07	5.03	0.0021	significant
A-Contaminant Volume	4.950E+05	1	4.950E+05	0.1054	0.7494	
B-Rainfall Intensity	3.461E+06	1	3.461E+06	0.7367	0.4027	
C-Soil Depth	1.312E+08	1	1.312E+08	27.92	< 0.0001	significant
AB	4.231E+05	1	4.231E+05	0.0901	0.7677	
AC	26824.78	1	26824.78	0.0057	0.9406	
BC	8.197E+06	1	8.197E+06	1.74	0.2040	
A ²	2.737E+06	1	2.737E+06	0.5825	0.4558	
B ²	3.245E+06	1	3.245E+06	0.6908	0.4174	
C ²	6.311E+07	1	6.311E+07	13.43	0.0019	significant
Residual	7.987E+07	17	4.698E+06			
Corrected Total	2.927E+08	26				

* sum of square, ** degree of freedom, *** mean square

Table 5. Coefficients in terms of coded factors, %retained

Factor	Coefficient Estimate	df	Standard Error	95% CI Low	95% CI High	VIF*
Intercept	3134.81	1	1103.64	806.32	5463.29	
A-Contaminant Volume	165.84	1	510.89	-912.04	1243.71	1.0000
B-Rainfall Intensity	438.49	1	510.89	-639.39	1516.37	1.0000
C-Soil Depth	2699.41	1	510.89	1621.53	3777.29	1.0000
AB	187.77	1	625.71	-1132.36	1507.90	1.0000
AC	47.28	1	625.71	-1272.85	1367.41	1.0000
BC	826.50	1	625.71	-493.63	2146.62	1.0000
A ²	675.36	1	884.88	-1191.58	2542.30	1.0000
B ²	735.45	1	884.88	-1131.49	2602.39	1.0000
C ²	3243.24	1	884.88	1376.30	5110.18	1.0000

*Variance Inflation Factor

The coefficient estimate represents the expected change in response per unit change in factor value when all remaining factors are held constant. The intercept in an orthogonal design is the overall average response of all the runs. The coefficients are adjustments around that average based on the factor settings. When the factors are orthogonal, that is the VIFs are 1; VIFs greater than 1 indicate multicollinearity, the higher the VIF the more severe the correlation of factors. As a rough rule, VIFs < 10 are tolerable.

$$\%R = 22828.2 - 15.3A - 2351.0B - 427.2C + 0.5AB + 0.01AC + 11.0BC + 0.03A^2 + 117.7B^2 + 3.6C^2 \quad (1)$$

The equation in terms of actual factors can be used to make predictions about the response for given levels of each factor (Eq. 1). Here, the levels should be specified in the original units for each factor. This equation should not be used to determine the relative impact of each factor because the coefficients are scaled to accommodate the units of each factor and the intercept is not at the center of the design space. Table 6 shows the comparison between experimental

and predicted values of the diesel and waste oil degradation. However, the ANOVA for the quadratic model is shown in Table 7.

The model F-value of 3.90 implies the model is significant. There is only a 0.76% chance that an F-value this large could occur due to noise. P-values < 0.0500 indicate model terms are significant. In this case, C, AB, C² are significant model terms. Values > 0.1000 indicate the model terms are not significant. If there are many insignificant model terms (not counting those required to support hierarchy), model reduction may improve your model. The predicted R² of 0.1888 is not as close to the adjusted R² of 0.5010 as one might normally expect; i.e. the difference is more than 0.2. This may indicate a large block effect or a possible problem with your model and/or data. Things to consider are model reduction, response transformation, outliers, etc. All empirical models should be tested by doing confirmation runs. Model Precision measures the signal to noise ratio. A ratio greater than 4 is desirable. However, the ratio of 6.869 indicates an adequate signal. This model can be used to navigate the design space. See coefficients

Table 6. Showing the experimental and predicted values for % retained diesel and waste oil in the soil

Run order	Experimental value	Predicted value	Residual
1	4323.50	5546.66	-1223.16
2	5757.12	4802.09	955.03
3	6997.67	5408.24	1589.43
4	3876.58	4235.44	-358.86
5	4263.63	3678.64	584.99
6	4286.54	4472.55	-186.01
7	2566.20	4395.12	-1828.92
8	4100.95	4026.08	74.87
9	5400.40	5007.77	392.63
10	3611.11	4129.06	-517.95
11	3000.93	3431.76	-430.83
12	1948.55	4085.19	-2136.64
13	4073.51	3644.33	429.18
14	4062.42	3134.81	927.61
15	3424.62	3976.00	-551.38
16	10241.05	4630.51	5610.54
17	3182.42	4308.75	-1126.33
18	3133.51	5337.71	-2204.20
19	9840.72	9197.94	642.78
20	9503.42	8547.92	955.50
21	9414.47	9248.63	165.84
22	9361.51	9539.71	-178.20
23	9214.53	9077.46	137.07
24	9161.53	9965.94	-804.41
25	8776.96	11352.38	-2575.42
26	8999.99	11077.90	-2077.91
27	15888.88	12154.14	3734.74

in terms of coded factors, amount of waste oil, and diesel leached in Table 8.

The coefficient estimate represents the expected change in response per unit change in factor value when all remaining factors are held constant. The intercept in an orthogonal design is the overall average response of all the runs. The coefficients are adjustments around that average based on the factor settings. When the factors are orthogonal the VIFs are 1; VIFs > 1 there is an indication of multi-collinearity, the higher the VIF the more severe the correlation of factors. As a rough rule, VIFs < 10 are tolerable. Additionally, Table 9 shows the experimental and predicted values, amount of waste oil, and diesel leached. The model in Eq. 2 can be used to make predictions based on the coded factors.

$$L = 6855.4 - 122.4A - 160.70B - 1673.26C + 1402.15AB + 163.9AC - 223.81BC - 843.0A^2 - 318.81B^2 - 3037.C^2 \quad (2)$$

Effect of rainfall intensities on the response variables

In this study, the result of the designed experiment from a 3³ factorial was analyzed in design

expert software (stat-ease software version 11) to determine the effect of one of the factors, rainfall intensity on the amount of a combination waste oil and diesel retained and leached in the soil studied. To show the effects, the analysis was subject to several conditions or constraints as follows, rainfall intensity was taken as 5mm/hr, 7.25, 9, and 10mm/hr respectively to measure the corresponding impact on the response variables. Oil spilled in the coastal zone may be remediated through biodegradation by naturally occurring bacteria, (Ebuehi *et al.*, 2005; Abu and Dike, 2008; Bravo-Linares *et al.*, 2012) that the rate of degradation may differ within the intertidal area due to many environmental factors (Mudge and Pereira, 1999; Wang and Stout, 2007). In this study, rainfall intensity has played a vital role in the entire degradation process (Ghazali *et al.*, 2004).

In Fig. 2 the cook's distance is shown, residual and normal plots of the amount of waste oil diesel leached or retained in the soil. Cook's distance is used to identify the points that negatively affect the

Table 7. ANOVA for quadratic model, response 2: amount of waste oil and diesel leached (mg/l) (R² = 0.6737)

Source	SS	df	MS	F-value	p-value	Remarks
Model	1.359E+08	9	1.510E+07	3.90	0.0076	significant
A-Contaminant Volume	2.698E+05	1	2.698E+05	0.0697	0.7949	
B-Rainfall Intensity	4.648E+05	1	4.648E+05	0.1201	0.7332	
C-Soil Depth	5.040E+07	1	5.040E+07	13.02	0.0022	significant
AB	2.359E+07	1	2.359E+07	6.10	0.0245	significant
AC	3.224E+05	1	3.224E+05	0.0833	0.7764	
BC	6.011E+05	1	6.011E+05	0.1553	0.6984	
A ²	4.264E+06	1	4.264E+06	1.10	0.3086	
B ²	6.099E+05	1	6.099E+05	0.1576	0.6963	
C ²	5.536E+07	1	5.536E+07	14.30	0.0015	significant
Residual	6.580E+07	17	3.870E+06			
Corrected Total	2.017E+08	26				

Table 8. Coefficients in terms of coded factors, amount of waste oil and diesel leached (mg/l)

Factor	Coefficient Estimate	df	Standard Error	95% CI Low	95% CI High	VIF
Intercept	6855.42	1	1001.72	4741.98	8968.86	
A-Contaminant Volume	-122.42	1	463.71	-1100.76	855.91	1.0000
B-Rainfall Intensity	-160.70	1	463.71	-1139.03	817.64	1.0000
C-Soil Depth	-1673.26	1	463.71	-2651.59	-694.92	1.0000
AB	1402.15	1	567.92	203.95	2600.36	1.0000
AC	163.92	1	567.92	-1034.29	1362.13	1.0000
BC	-223.81	1	567.92	-1422.02	974.40	1.0000
A ²	-843.00	1	803.16	-2537.52	851.53	1.0000
B ²	-318.81	1	803.16	-2013.34	1375.71	1.0000
C ²	-3037.42	1	803.16	-4731.94	-1342.89	1.0000

Table 9. Showing the experimental and predicted values, amount of waste oil and diesel leached (mg/l)

Run order	Experimental value	Predicted value	Residual
1	5134.80	5954.83	-820.03
2	6233.24	5109.33	1123.91
3	1000.55	2577.83	-1577.28
4	4129.46	4934.60	-805.14
5	4920.93	5491.26	-570.33
6	5011.82	4361.92	649.90
7	4411.90	3276.74	1135.16
8	5348.81	5235.56	113.25
9	6258.93	5508.37	750.56
10	9899.03	7378.88	2520.15
11	9898.57	6697.30	3201.27
12	1295.36	4329.72	-3034.36
13	4351.02	6134.84	-1783.82
14	6239.91	6855.42	-615.51
15	9459.96	5890.00	3569.96
16	3366.10	4253.18	-887.08
17	4718.02	6375.91	-1657.89
18	5499.92	6812.64	-1312.72
19	1077.77	2728.09	-1650.32
20	1211.91	2210.43	-998.52
21	1241.97	6.78	1235.19
22	1365.76	1260.25	105.51
23	1444.96	2144.74	-699.78
24	1492.45	1343.24	149.21
25	1340.34	-845.23	2185.57
26	1545.03	1441.43	103.60
27	1611.63	2042.08	-430.45

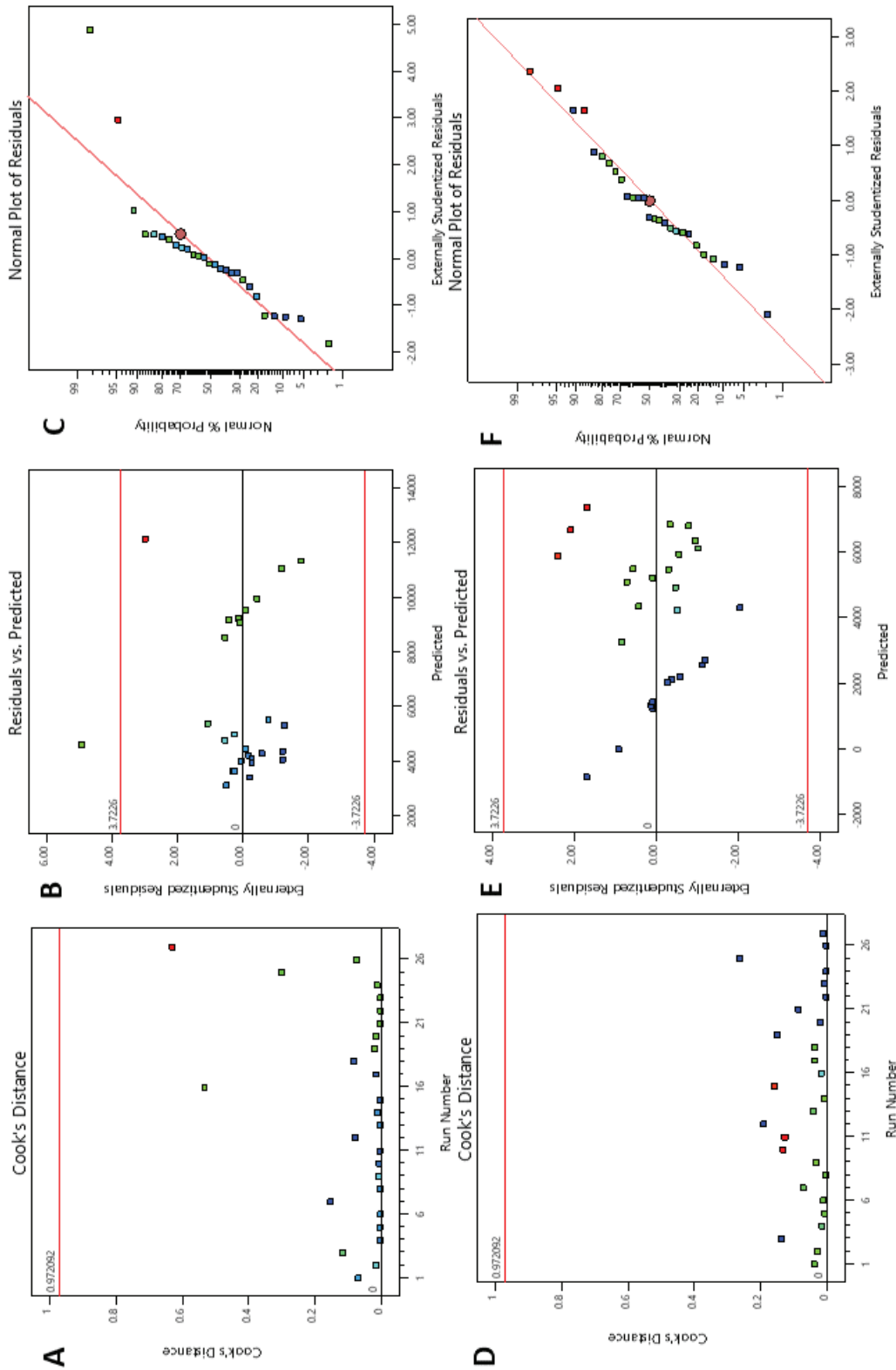
quadratic model in Eq. 1 and 2. Because of this, it was observed that 3 points affect the model amount of oil retained while 1 point affects the amount of oil leached (Figs. 2A and D). However, this outcome does not have a significant impact on the quadratic model. Again, as shown in Figs. 2B and 2E, residual is the difference between the experimental value of the dependent variables (retained and leached) and the predicted values of the same variable. However, the smaller the residual the stronger the correlation between predicted and experimental values. It was observed that the model describing the amount of waste oil and diesel leached has lower residuals. All points fall within the red lines as shown in Fig. 2E which is an indication that this model fits better or has a strong correlation than that of the amount of oil retained in the soil. Similarly, the normal plot vs the residual shows how the predicted (model) correlates with the experiment. In this case, the amount of oil leached fits better than the one retained (Figs. 2C and F) which confirms the previous plots in Figs. 2B and E.

Three-dimensional response surface plots

were used to graphically represent the regression equation. It shows significant mutual interaction between the independent variable and the response (Zaheda et al., 2010). In Fig. 3 it was observed that at 5mm/hr rainfall intensity the amount of oil leached decreases at higher soil depth, the contaminant volume also decreases as shown in the 3D surface plots of Fig. 3A also in the contour plots. While the amount of oil retained in the soil increases as lower rainfall intensity. Similarly, the soil depth decreases as contaminant volume increases. Depending on soil type, nature of the pollutants, etc. An increase or reduction in rainfall, as well as changes in frequency and distribution of rainfall associated with climate change, can certainly affect soil microbial activity and, hence, microbial degradation of soil pollutants in natural attenuation (Itziar et al., 2017).

Increasing the rainfall intensity to 7.25mm/hr, the amount of waste oil and diesel leached reduces, the soil depth increased significantly as the contaminant volume decreases. While the amount retained increases (Fig. 4) just like the first case Fig. 3. As

Fig. 2. Showing the (A) Cook's distance (B) Residual plot and (C) Normal plot for the amount of waste oil and diesel retained in the soil (D), (E) and (F) showing the plots on the effect of the amount of waste oil and diesel leached through the soil



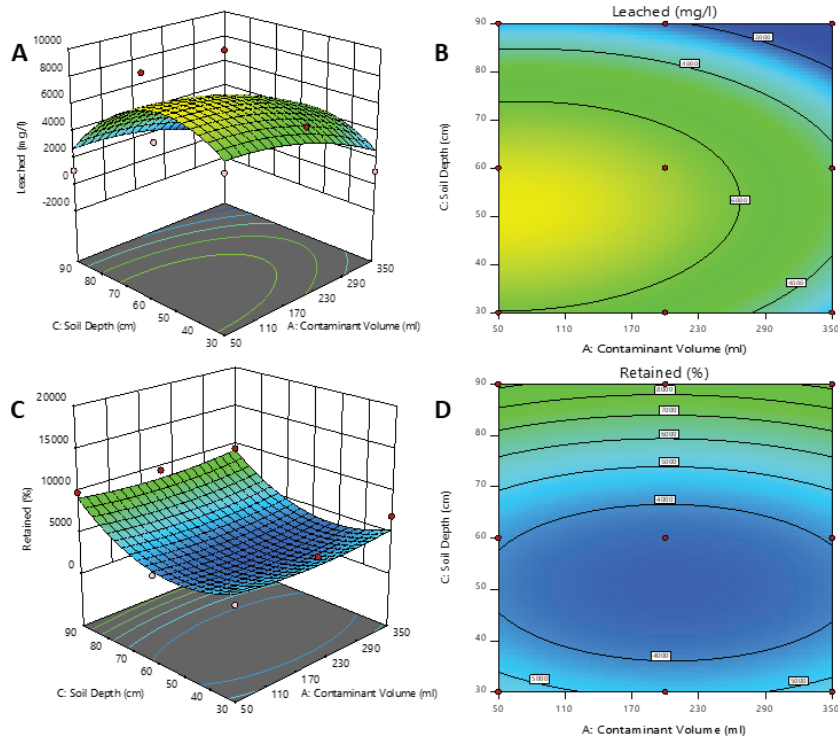


Fig. 3. Showing the 3D surface and contour plots (A, B) Effect of soil depth and contaminant volume on leached (C, D) effect of contaminant volume and soil depth on retained at 5mm/hr rainfall intensity.

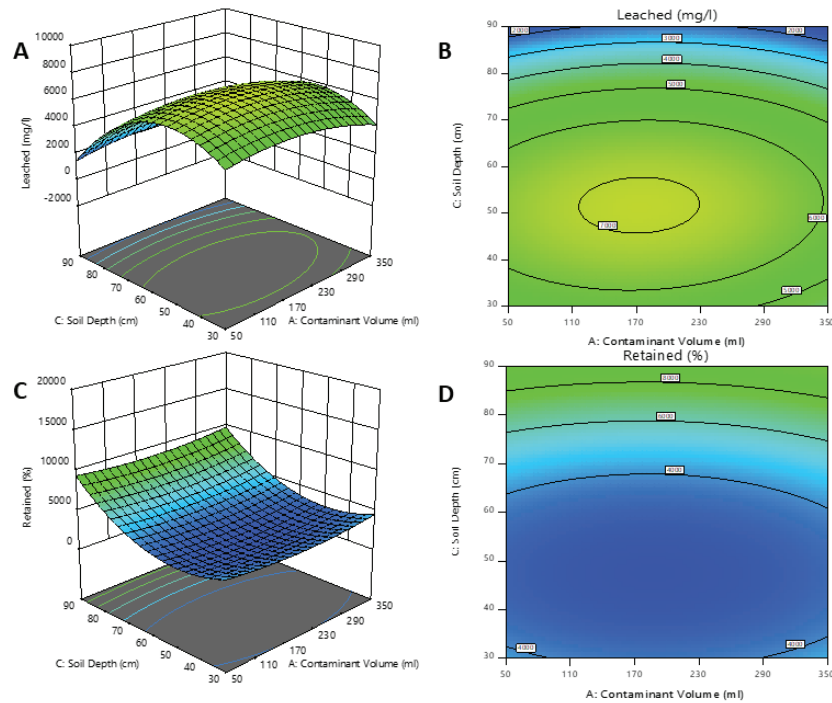


Fig. 4. Showing the 3D surface and contour plots (A, B) Effect of soil depth and contaminant volume on leached (C, D) effect of contaminant volume and soil depth on retained at 7.25mm/hr rainfall intensity.

shown in the 3D surface plots and contour graphs, soil depth decreases as contaminant volume increases. The amount of oil leached and retained in the soil is significantly impacted by rainfall intensities as shown in Figs. 3 and 4. Because many climate-induced (rainfall intensities) effects on soil microorganisms occur indirectly through changes in plant growth and physiology derived from increased atmospheric CO₂ concentrations and temperatures, the alteration of rainfall patterns, etc., with a concomitant effect on rhizoremediation performance (i.e. the plant-assisted microbial degradation of pollutants in the rhizosphere).

Again, in Fig. 5, It shows that at 9mm/hr rainfall there was a significant reduction in the amount of oil (waste oil and diesel) leached through the soil with higher soil depth as contaminant volume decreases (3D surface plots and contour graphs in Figs. 5A and B). Also, in Figs. 5C and D there is a significant increase in the amount of oil retained in the soil at lower soil depth

depth and higher contaminant volume.

At 10mm/hr rainfall there was a significant reduction in the amount of oil (waste oil and diesel) leached through the soil with higher soil depth as contaminant volume decreases (3D surface plots and contour graphs in Figs. 6A and B). Also, in Figs. 6C and D there is a significant increase in the amount of oil retained in the soil at lower soil depth and higher contaminant volume.

Nevertheless, the significance of the impact of the different rainfall intensities is dependent on the soil depth. According to EPA (2017), aerobic biodegradation is most effective in soils that are relatively permeable to allow the transfer of oxygen to subsurface soils where the microorganisms are degrading the petroleum constituents. The EPA report stated that, the length of time required for oxygen to diffuse into the soil increases as the depth increases. The diffusion rate is also proportional to the air-filled porosity of the soil

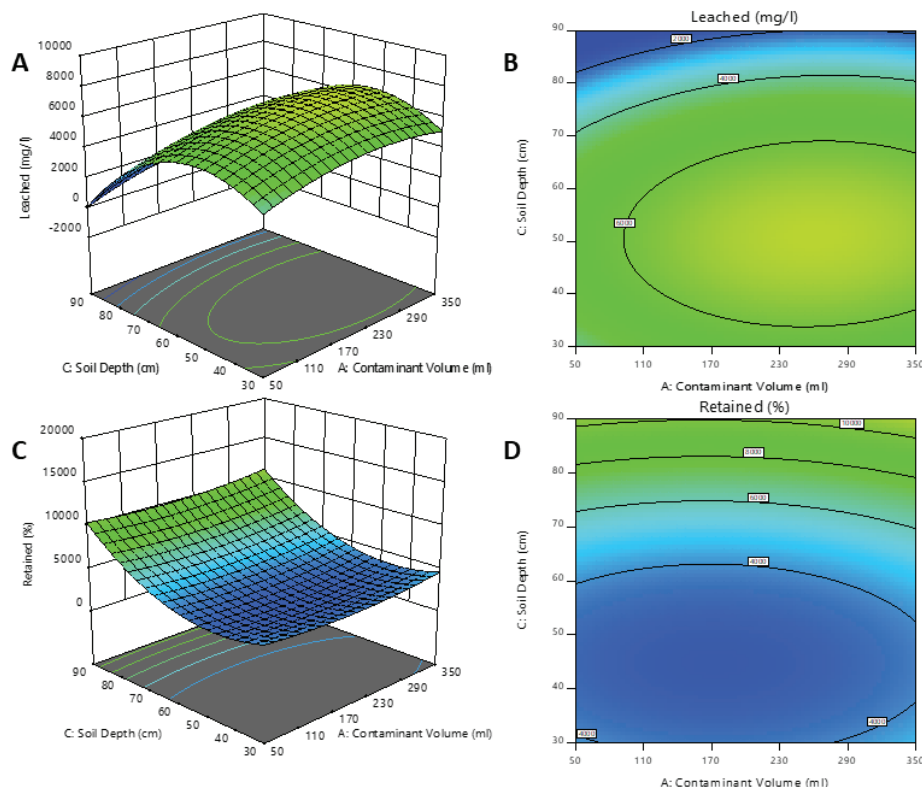


Fig. 5. Showing the 3D surface and contour plots (A, B) Effect of soil depth and contaminant volume on leached (C, D) effect of contaminant volume and soil depth on retained at 9mm/hr rainfall intensity.

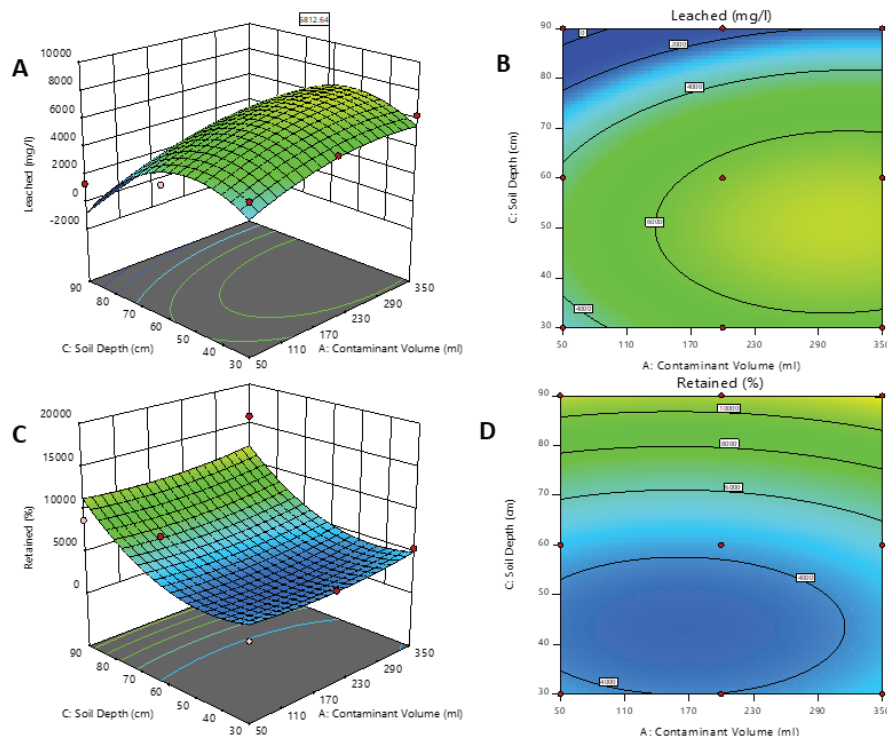


Fig. 6. Showing the 3D surface and contour plots (A, B) Effect of soil depth and contaminant volume on leached (C, D) effect of contaminant volume and soil depth on retained at 10mm/hr rainfall intensity (at the peak of the rainfall).

CONCLUSION

The current study investigated the factors affecting the amount of waste engine oil and diesel leached and retained in the soil after biodegradation. Three independent variables were screened through statistical experimental design and RSM analysis to select the most significant variables that affected oil degradation. Successively it was found that rainfall intensity has a significant impact on the amount of engine oil leached and retained in the soil. Although the amount of engine oil leached is inversely proportional to the amount retained as impacted by different rainfall intensities, it was observed that as the rainfall intensity increases, the amount of engine oil leached decreases at higher soil depth while the amount of engine oil retained increases at lower soil depth. Nevertheless, the significance of the impact of the different rainfall intensities is dependent on the soil depth. This means that the variation in soil depth also affects the process of rainfall intensity in reducing the amount of waste engine oil and diesel in the soil.

On the model validation, the residual shows the difference between the experimental value of the dependent variables (i.e. retained and leached) and the predicted values of the same variable. The lower the residual, is an indication of a significant relationship between predicted and experimental values. Additionally, It was observed that the model describing the amount of waste oil and diesel leached has lower residuals which indicates a high level of accuracy.

Therefore with the regression coefficient at 72% for retained and 67% for leached concentrations, this implies that the quadratic model is accurate, effective and highly recommended for use.

AUTHOR CONTRIBUTIONS

Theophilus, O.N. commenced the process by conceptualizing and formulating the research idea, followed by data collection and cleaning, and was also extensively involved in reviewing literature and preparing the manuscript. Akaranta, O. reviewed and edited the final manuscript. Theophilus, O.N.

performed the data analysis, results interpretation, and discussion. Ugwoha, E. reviewed the analyzed data and helped in the data interpretation. Theophilus, O.N. did the proofreading and literature review.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest regarding the publication of this manuscript. In addition, the ethical issues, including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, and redundancy have been completely observed by the authors.

ABBREVIATIONS

<i>BTS</i>	Base transreceiver station
<i>DGs</i>	Diesel generators
<i>DOE</i>	Design of experiment
<i>EPA</i>	Environmental protection agency
<i>NIMET</i>	Nigerian meteorological agency
<i>PAHs</i>	Polycyclic aromatic hydrocarbons
<i>PCBs</i>	Polychlorinated biphenyls
<i>POPs</i>	Persistent organic pollutants
<i>RSM</i>	Response surface methodology

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CASE STUDY

Organizational culture and its impact on organizational productivity

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ABSTRACT

BACKGROUND AND OBJECTIVES: Organizational culture is a topic that has recently emerged in management knowledge and in the domain of organizational behavior. Following new theories and research in management, organizational culture has become increasingly important and has become one of the central focus of management. The purpose of this study was to investigate the dimensions and indicators affecting organizational culture in order to improve organizational culture and productivity based on the Denison Model in District 19 of the Municipality of Tehran, Iran.

METHODS: The research method was descriptive-correlational and Denison's organizational culture questionnaire which assesses organizational culture based on four dimensions of involvement in work, compatibility, adaptability and mission were used. Each of these four dimensions has three defined indicators. The statistical population of the study consisted of all employees of District 19 of Tehran Municipality, 148 of whom completed the questionnaire. After analyzing the data, the frame of the organizational culture of the district was formed.

FINDINGS: The results showed that the mission and involvement in work have the mean scores of 3.14 and 3.01, respectively while adaptability and compatibility showed the mean score of 3.12 and 3.07.

CONCLUSION: The municipality of District 19 in terms of its organizational missions and strategic goals needs a well-constructed plan.

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INTRODUCTION

Organizational culture as a new found topic paid particular attention in management knowledge and organizational behavior, recently focused as focal of management. Demographers, sociologists, and more recently psychologists and even economists have paid special attention to this new and important issue in management (Osborne, 2013). To this aim, many theories and researches were created and used to identify the role and importance of Organizational culture and management problems. A study by a group of management specialists determined organizational culture as one of the most influential factors in the development of countries (Hogan and Coote, 2014). As many researchers believe, the success of Japan in industry and management is essentially due to their attention to organizational culture (Nahm *et al.*, 2004). Organizational culture is collection of beliefs, assumptions, values and interaction methods which lead to exclusive social and spiritual environ of an organization (Hartnell *et al.*, 2011; Alvesson, 2012). Organizational culture includes the organization's expectations, experiences, philosophy, as well as the values that guide the behavior of board members contained members' self-image, internal affairs, interaction with the outside world, and future expectations (Kasemsap, 2015). Culture is written based on attitudes, beliefs, customs, and rules developed and validated over time. Culture also includes the organization's perspective, values, norms, systems, symbols, language, assumptions, beliefs, and habits (Needle, 2004). While the above cultural definitions indicate how structure plays a role in the workplace, other definitions emphasize employee's behavioral components (Yilmaz, 2014) and how organizational culture directly affects employee behavior in an organization. According the above definitions, organizational culture is a complex of common assumptions that guide what happens in organizations by defining appropriate behavior for different situations (Ravasi and Schultz, 2006; Alvesson, 2012). Organizational culture influences how individuals and groups interact with each other, with customers, and with stakeholders (Hueske and Guenther, 2015). Organizational culture may also influence on employees interact with their organization (Schrodt, 2002; Ardichvili *et al.*, 2009). To understand and manage organizational culture, the primary step is to know the prevailing culture

in the organization (Rainey, 2009). Various solutions and models have been presented so far. Among the presented models, Denison *et al.*, (2000) model has several important and basic features. Firstly, the model is very simple and clear. Simple in terms of understanding the concepts and recognizing its various dimensions. Secondly, the model is quite practical. In various companies, organizations and units, including manufacturing and services, etc., shows high practicality of Dennison Model. Thirdly, the results are completely understandable and related to various organizational issues. The results provide a good basis for changing organizational culture and its improvement and ultimately the productivity of the organization. Denison's organizational culture model can be used as a powerful tool to understand organizational culture and the effects on various dimensions of organizational productivity. It is used in most organizations and increases efficiency by improving each indicator and characteristics of organizational culture (Denison, 2010). Denison *et al.*, (2000) presented four components for examining and evaluating organizational culture and delared that it is essential to achieve better performance and increase productivity. The Denison model is shown in Fig. 1.

Denison *et al.*, (2000), by research on organizational culture and organization effectiveness, described the cultural characteristics as follows:

- Involvement in work
- Compatibility
- Adaptability
- Mission

Each feature is measured by three indicators, including:

Involvement in work

Effective organizations empower their individuals, form organizations based on work groups, and develop human resource capacities at all levels. Members of the organization are committed to their work and feel part of the organization. People at all levels feel involved in decision-making, and it is their decisions that affect their work, and their work is directly linked to the goals of the organization.

- Empowerment: People have the authority, initiative and ability to manage their work. This creates a sense of ownership and responsibility in the organization

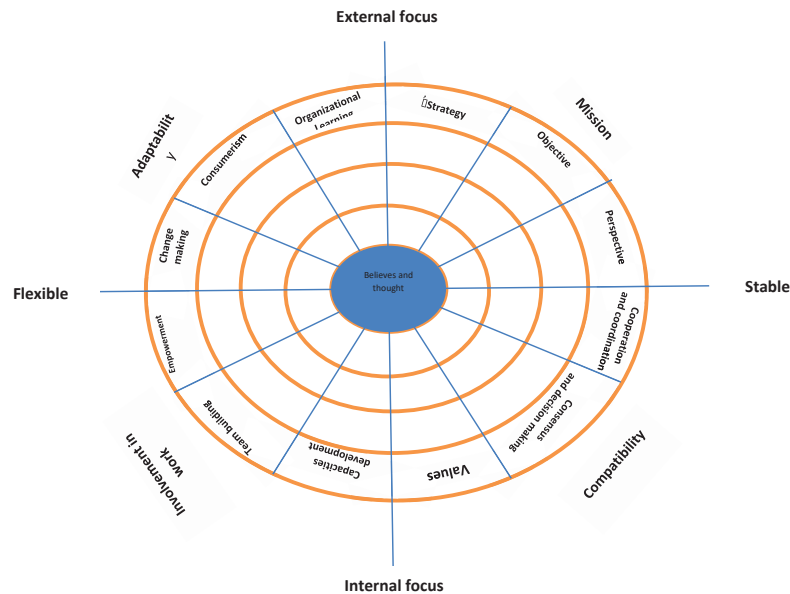


Fig. 1- Denison Organizational Culture Model (Denison et al., 2000)

- Team building: In the organization, teamwork is valued for common goals. As employees feel like managers, they are responsible at work. These organizations rely on groups to do things.
- Capacity development: The organization continuously develops employee skills in order to meet needs and stay competitive.

Compatibility (cohesion and integration)

Organizations that are often effective, are stable and integrated, and employee behavior show fundamental values. Leaders and followers are skilled at reaching an agreement (even when they have a reciprocal view) and organizational activities are well coordinated. Organizations with such characteristics have a strong and distinct culture and sufficient influence on employee behavior. This feature is examined with three indicators:

Fundamental values: Members of the organization share a set of values that shape their identity and expectations.

- Agreement: Members of the organization are able to agree on important differences. This agreement includes both the agreement at the lower level and the ability to reach an agreement at other levels.
- Coordination and coherence: Organizational units with different functions can work very well

together to achieve common goals. Organizational boundaries are not blurred by such work.

Adaptability

Organizations that are well integrated, change difficultly. Therefore, internal integration and external adaptability can be considered as the advantage and superiority of these organizations. Compatible organizations are guided by customers, they take risks, make mistakes, and have the capacity and experience to make a difference. They are constantly improving the organization's ability to value customers. This feature is examined with three indicators:

- Change Making: The organization is able to create ways to meet the needs of change and can recognize the environment, respond to current motivations and forecast future changes.
- Customerism: The organization appreciates and responds to customers and seeks to secure the future in advance. In fact, customerism shows the orientation to which organizations are driven by customer satisfaction.

Organizational Learning: Measures the amount of environmental cues that organizations receive, translates, and interprets, and measures the opportunities it creates to encourage creativity, knowledge, and development.

Mission

It might be mentioned that the most important feature of organizational culture is its mission. The organizations that don't know where they are and what is their current situation? They usually go astray. Successful organizations have a clear understanding of their organizational and strategic goals. Hence, they define organizational and strategic goals and outline the organization's perspectives. This feature is examined with three indicators:

- Strategic trend and orientation: Clear strategic orientations show the direction of organizational goals and each individual can participate in that section.
- Goals and objectives: Goals are linked to the organization's strategy, mission, and perspective, and determine the direction of people's work.
- Perspective: The organization has a common perspective of the future. It expresses a fundamental value, merge the thoughts and hearts of the human resources, and simultaneously determines the direction.

Fixed-Flexible Spectrums and Internal-External Focus: As seen, Denison Model has two vertical and horizontal axes that classify the model into four parts (quarters). The vertical axis includes the amount and type of focus of organizational culture. This axis leads to internal focus on the one hand and external focus on the other. The horizontal axis also refers to the degree of flexibility of the organization, which on the one hand leads to static culture and on the other hand to flexible culture (Denison *et al.*, 2000). In this regard, Vahidnia and Vafaei (2005) studied on an article entitled "Pathology of organizational culture in establishing the productivity cycle in organizations". Results show that the role of internal factors of the organization, especially the financial management of the quality system and productivity growth is very high. Although external factors are also influential, their role is less and about 15-20%. In an article entitled "Investigating the impact of organizational culture on the performance of employees of Chofa Company", Morovati Sharifabadi (2005) used the Performance Evaluation Model and Seven Factor Model of Robbins, (2011). to evaluate performance and organizational culture, respectively. A positive correlation between organizational culture and performance was Approved. Atafar *et al.*, (2012) in a paper entitled "Pathology of Work and Efforts Culture

to Promote Productivity in Iran", used a cross-cutting approach to investigate in line with work culture, productivity and ultimately growth. Mabaleghi and Danesh (2014) in an article entitled "Study of variables affecting organizational culture in order to improve organizational culture and productivity in the Export Guarantee Fund of Iran" examined the model in the organization. Lacas (2010) in a research entitled "Multi-model analysis of organizational culture using the improved study of Denison organizational culture in the United States" presents a field method for recognizing and improving organizational culture. Ardakani *et al.*, (2012) in a study entitled "Investigating the dimensions of organizational culture based on Denison Model and also based on the opinions of faculty members of Islamic Azad University, Gachsaran Branch" found that among the dimensions of organizational culture participation and adaptability showed the highest and the lowest score, respectively. Based on the average score achieved for the twelve indicators of organizational culture, team building, capacities development and fundamental values have the highest score based on the opinions of faculty members of Islamic Azad University, Gachsaran Branch. In their study, Ardalan *et al.*, (2008) examined the relationship between organizational culture and individual-organizational unity using Denison Model in public universities in the west of the country. Results showed that all four dimensions of Denison's organizational culture Model is dominant in the country's western universities. Also, in this study, it was found that mission and involvement in work dimensions had the highest and the lowest correlation with organizational criteria of individual-organizational unity, respectively. Gillespie *et al.*, (2008) evaluated the relationship between organizational culture and customer satisfaction in the building construction industry and car dealers. They have used the Denison Model to understand organizational culture. Results show that the highest and the lowest score in the building construction industry is obtained in terms of involvement in work and mission, and adaptability, respectively. Also, in case of car dealers, the highest and lowest score obtained for Adaptability and Compatibility dimensions, respectively. The environment of organizations is constantly changing. Changes in technology, such as technology-based executive activities, have led to huge leaps in

communication information, business processes, and business practices. On the other hand, the move towards globalization and access to free markets has led organizations to prepare themselves for rapid environmental change (Abolghasemi *et al.*, 2018). Most managers, meanwhile, certainly have a broad perspective on culture and its role in creating a motivating work environment. However, they pay attention to culture as a key reason for organizational change (Schein, 2010). Today, the importance of productivity in the value chain of organizations is such that it is considered as the most effective indicator of determining the success rate of organizations and their competitive advantage. But, most organizations, especially governmental ones, have low productivity, and they certainly need to take major steps to improve the organization's culture in order to achieve high productivity (Carmeli and Tishler, 2004). Organizational culture as an influential factor is a lever to improve productivity (Eisend *et al.*, 2016). Basically, the purpose of addressing productivity or improving productivity in organizations is to increase competition in various business scenes and make more profit. However, it will not be achieved except by attention to the organization culture (Varizi *et al.*, Mansouri, 2010). Given the importance of productivity in organizational and social life, to identify and study the organizational culture in the District 19 of Municipality of Tehran, was selected. In addition to research conducted in the United States, other studies in China, Russia, and Taiwan validated and supported Denison Model. The main question of the present research is what is the current situation of the District 19 of Municipality of Tehran based on the Denison Model? The research sub-questions are as follows:

- In terms of involvement in the work variable, what is the status of the organizational culture in the District 19 of Municipality of Tehran?
- In terms of adaptability variable, what is the status of the organizational culture in the District 19 of Municipality of Tehran?
- In terms of adaptability variable, what is the status of the organizational culture the District 19 of Municipality of Tehran?
- In terms of mission variable, what is the status of the organizational culture in the District 19 of Municipality of Tehran?

The main purpose of the current is to identify

the organizational culture in the District 19 of Municipality of Tehran and the sub-objectives are awareness of the status of the variables, including mission, compatibility, adaptability and involvement in the work of the municipality of District 19 of Municipality of Tehran. The current study has been carried out in Tehran in 2019.

MATERIALS AND METHODS

This research is applicable and descriptive in terms of purpose and data collection respectively and of survey group, which examines the organizational culture of the municipality of District 19. Data were provided by a questionnaire and library study. The general questions were divided into two categories: demographic questions and attitude questions. Demographic questions are the general characteristics of respondents such as gender, age, education and work experience. Attitude Questions were used to discover the respondents' views and opinions about the characteristics and indicators of organizational culture based on the theoretical framework of the Denison's questionnaire. This questionnaire converts qualitative factors into small amounts using a 5-part Likert spectrum. Spss software was used for statistical analysis. In order to investigate the significant difference, t-test with hypothetical mean 3 was used to obtain the mean score. The statistical population includes 200 people, of which 148 answered the distributed questionnaire.

RESULTS AND DISCUSSION

The present study aims to obtain an overview of the governing organizational culture in the District 19 of Municipality of Tehran. According to the results, 60% and 40% of respondents are women and men, respectively. The highest age group is between 30 and 39 years (57%). The highest percentage of people's educational degrees is bachelor (47%), master degree (28%), post-diploma (14%), diploma (10%) and doctorate (1%) which indicates the average level of education between individuals, respectively. The highest percentage of work experience of people with 40% is related to people with work experience between 11 and 20 years.

Organizational culture dimensions

Considering the Likert spectrum from 1

(completely agree) to 5 (completely disagree) and calculating the mean as a measurement index, the following information is obtained. According to the Table 1 of the average scores of dimension of the mission with an average score of 3.14 and the involvement in the work dimension with the average score 3.01 had the highest and lowest scores, respectively, from organizational dimensions.

In order to investigate the significant difference, t-test with hypothetical mean 3 was used to obtain the mean score (Table 2).

The t-test was used to investigate the significant difference between the obtained mean scores and the hypothetical mean of 3. This test showed that in terms of employees of the municipality of District 19, the dimensions of adaptability and mission in organizational culture have an unfavorable situation, and the dimensions of involvement in work and compatibility are also in a moderate position. The Pearson test was used to investigate the correlation between the dimension of involvement at work and its indicators at the error level of 0.01%. The obtained result indicates a significant relationship

between the dimension of involvement in work and its indicators. Also, the empowerment index has the most relationship with the dimension of involvement at work (Table 3).

Table 4 shows a very good correlation between the integration dimension and its indicators at the error level of 0.01%, and the agreement index has the most correlation with the fundamental value.

Table 5, Correlation of compatibility and dimensions of organizational culture. The correlation between the adaptability dimension and its indicators at the error level of 0.01% is very high and the index of change making has the most correlation with the flexibility dimension.

Table 6 shows that the correlation between the mission dimension and its indicators at the 0.01% error level, is very high, and the target and mission index is the most relevant index with the the mission.

Correlation between dimensions of organizational culture

Examining Table 7, in the correlation between the dimensions of organizational culture, the two

Table 1. The average scores dimensions

One-Sample Statistics			
Organizational culture indicators	N	Mean	Std. Deviation
Involvement in work	147	3.0166	.72751
Compatibility	147	3.0756	.58506
Adaptability	147	3.1247	.58667
Mission	147	3.1493	.74614

Table 2. The results of One-Sample Test

Organizational culture indicators	Test Value = 3					
	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
Involvement in work	.277	146	.782	.01663	-.1020	.1352
Compatibility	1.566	146	.119	.07559	-.0198	.1710
Adaptability	2.577	146	.011	.12472	.0291	.2203
Mission	2.426	146	.016	.14928	.0277	.2709

Table 3. Correlation of involvement in work and dimensions of organizational culture

		Empowerment	Team building	Capacities development
Involvement in work	Pearson Correlation	.908**	.900**	.874**
	Sig. (2-tailed)	.000	.000	.000
	N	147	147	147

** Correlation is significant at the 0.01 level (2-tailed).

Table 4. Correlation of compatibility and dimensions of organizational culture

		Values	Consensus and decision making	Cooperation and coordination
Compatibility	Pearson Correlation	.875**	.892**	.666**
	Sig. (2-tailed)	.000	.000	.000
	N	147	147	147

** Correlation is significant at the 0.01 level (2-tailed).

Table 5. Correlation of adaptability and dimensions of organizational culture

		Change making	Consumerism	Organizational Learning
Adaptability	Pearson Correlation	.849**	.818**	.818**
	Sig. (2-tailed)	.000	.000	.000
	N	147	147	147

** Correlation is significant at the 0.01 level (2-tailed).

Table 6. Correlation of mission and dimensions of organizational culture

		Perspective	Objective	Strategy
Mission	Pearson Correlation	.779**	.922**	.665**
	Sig. (2-tailed)	.000	.000	.000
	N	147	147	147

** Correlation is significant at the 0.01 level (2-tailed).

Table 7. Correlation between dimensions of organizational culture

		Compatibility	Adaptability	Mission
Involvement in work	Pearson Correlation	.821**	.693**	.723**
	Sig. (2-tailed)	.000	.000	.000
	N	147	147	147

** Correlation is significant at the 0.01 level (2-tailed).

Table 8. The average score of organizational culture indicators in District 19 of municipality of Tharan

Organizational culture indicators	Empowerment	Team building	Capacities development	Values	Consensus and decision making	Cooperation and coordination	Change making	Consumerism	Organizational Learning	Strategy	Objective	Perspective
Mean	3.235	3.017	2.798	3.007	3.143	3.077	3.184	3.116	3.075	3.212	2.98	3.256
Std. Deviation	0.795	0.846	0.8	0.787	0.794	0.539	0.728	0.746	0.65	0.894	0.943	0.715

dimensions of adaptability, and involvement in work have the most correlation among the employees of the municipality of District 19.

The average score of of organizational culture

indicators in District 19 of municipality of Tharan is shown in [Table 8](#).

By examining the indicators of organizational culture, perspective has the highest score of 4.344,

Table 9. The results of One- Sample Test of the organizational culture indicators

One-Sample Test						
Organizational culture indicators	Test Value = 3					
	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
Empowerment	3.577	146	0	0.23469	0.10503	0.36435
Team building	0.244	146	0.808	0.01701	-0.1209	0.15487
Capacities development	-3.058	146	0.003	-0.2018	-0.3322	-0.0714
Values	0.105	146	0.917	0.0068	-0.1214	0.13502
Consensus and decision making	2.182	146	0.031	0.14286	0.01346	0.27225
Cooperation and coordination	1.733	146	0.085	0.0771	-0.0108	0.165
Change making	3.058	146	0.003	0.18367	0.06497	0.30238
Consumerism	1.879	146	0.062	0.11565	-0.006	0.23725
Organizational Learning	1.395	146	0.165	0.07483	-0.0312	0.18082
Strategy	2.876	146	0.005	0.21202	0.06632	0.35772
Objective	-0.262	146	0.793	-0.0204	-0.1741	0.13331
Perspective	4.344	146	0	0.25624	0.13965	0.37282



Fig. 2 - Indicators Chart of Organizational culture dimensions for District 19

and Capacities development with the score of -3.058, has the lowest score in organizational culture (Table 9). According to the questionnaire items, where the number (1) is considered to be completely positive to the number 5 as completely opposite, the result showed that the numbers above 3 have determined the unfavorable situation in that indicators.

Therefore, by using the results of t-test and reviewing Fig. 1, it is found that empowerment indicators, vision, change making, strategic guidance, and agreement have an inappropriate status, and capacity development index has an acceptable status in organizational culture from the perspective of

employees in the Municipality of District 19 (Fig. 2).

According to the results obtained among the four dimensions tested, the highest score of 3.14 is related to the mission dimension (Keeping in mind the given score of the questionnaire items). According to the t-test, there is a significant difference with the mean value, and the high average of this dimension means that the municipality of District 19 is not well defined in terms of its organizational goals and strategic goals and needs to draw a roadmap for itself. Also, the adaptability dimension was 3.12, which is a sign of weakness in this dimension. In other words, this district performance in internal integration and external adaptability are not

very strong. In two other dimensions of involvement in work and compatibility is in a moderate position. That is to say, the participation of the members of the organization in the work and knowing themselves as a member of the organization are in a moderate position. Also, the stability and integrity of the organization and the adherence of employees to fundamental values are at a moderate level. Managers and employees have reached a level of skill in reaching an agreement, and organizational activities have been coordinated to the extent of solving basic problems. Also, by examining the indicators of organizational culture, it is found that empowerment indicators (people have the authority, initiative, and ability to manage their work) with an average of 3.23, perspective (the organization has a common view of the future situation) with an average of 3.25, Make a change (the organization is able to make changes to meet the needs and can recognize the environment of the institution) with an average of 3.18, strategic guidance (having clear strategic goals for organizational goals) with an average of 3.21 and agreement (members of the organization are able to Agree on a significant difference) with an average of 3.14 has an unfavorable situation and an indicator of capacity development (the organization continuously develops staff skills to meet the needs and stay in the competition scene) with the average of 2.79 has an acceptable status in the District 19 of Municipality of Tehran.

CONCLUSIONS

Nowadays, considering the inevitable evolution of organizations which operates as an open system, not a closed system, they are forced to pay more attention to organizational culture in order to survive. This study attempted to answer the main questions by collecting information using a questionnaire. The purpose of this study was to investigate the dimensions and indicators affecting organizational culture in order to improve organizational culture and productivity based on the Denison Model in District 19 of the Municipality of Tehran, Iran. The research method was descriptive-correlational and Denison's organizational culture questionnaire which assesses organizational culture based on four dimensions of involvement in work, compatibility, adaptability, and, the mission was used. The results showed that that the mission and involvement in work have the mean scores of 3.14 and 3.01, respectively while adaptability and compatibility showed the mean score

of 3.12 and 3.07. In other words, the municipality of District 19 in terms of its organizational missions and strategic goals needs a well-constructed plan in order to achieve a better performance and productivities.

Suggestions

In general, managers should pay more attention to employees and their work in order to improve and eliminate the weakness of the organization in the studied district. Also, special facilities should be considered so that employees have more cooperation in order to make changes. Also, the managers of the organization should provide appropriate solutions to improve the working methods in the organization to achieve growth, excellence and productivity. Also, according to the obtained results, suggestions for improving the organization are presented: Increase staff awareness of the organization's goals, explanatory courses to increase employee's collaboration to make changes in the organization, gain new skills and professional development with the help of new training methods, help colleagues when needed and participate in teamwork. Eventually, it is suggested to perform similar study in other 22 districts in order to gain an overview of the organizational culture governing the Municipality of Tehran.

AUTHOR CONTRIBUTIONS

S. Mohammadi, has performed the methodology, literature review, software analysis, result interpretation, data collection, writing original draft preparation, funding acquisition, and prepared the manuscript text and agreed to the published version of the manuscript.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest regarding the publication of this manuscript. In addition, the ethical issues, including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, and redundancy has been completely observed by the authors.

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