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Evaluating environmental effects in construction and demolition waste recycling plant with the Iranian Leopold Matrix method

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ABSTRACT

BACKGROUND AND OBJECTIVES: Recycling and reusing construction and demolition debris is a productive step toward solving this problem. Still, the recycling process also leaves industrial effluents, which is evident in producing recycled sand. The present research has investigated the environmental effects of recycling construction debris at sand recycling plants. Considering the negative impacts of sand washing mud produced at the plant in the Aab'Ali Landfill of Tehran in Iran, the material's physicochemical characteristics and environmental impact have also been investigated to regulate practices.

METHODS: The Environmental Impact Assessment has been carried out in physicochemical, biological, socio-cultural, and economic-technical areas. Due to the large dispersion of the studied soil and the composition diversity in each sampling, 30 samples of the sand washing mud and the material mixed with the surrounding soil have been collected. The exploitation phase during the factory construction plan's implementation stage was considered the current research's main phase. Hence, 13 micro activities and 23 environmental parameters were identified, and the results were analyzed in the Environmental Impact Assessment Plus Software using the Iranian Leopold Matrix method and discussed based on the results of the experiments.

FINDINGS: According to the results of the matrix calculation, the three micro-activities included washing the sand through a sand-washing machine, fine sand washing through the EvoWash machine with a score of-3.6, converting concrete pieces and large boulders into smaller pieces by jackhammers, transferring to the jaw crusher machine with a score of-2.8, and transferring the remaining sand washing mud produced by the EvoWash machine to the storage pond with a score of-2.7 had the most negative effects. The three micro-activities of waste processing for green space irrigation (+2.2), selling products (+0.9), and hiring employees with a score of +0.5 have the most positive effects on the environment. As ranking smaller than-31 forming 50% of the total average of rows and columns, the activity of the plant and the sand extraction process in this landfill is approved by providing modification alternatives.

CONCLUSION: Considering the positive impact on the economy, increasing green spaces in the region, job creation, and also reducing the amount of increasing debris accumulated in the landfill is evaluated positively and can be done considering the reforms; including the prevention of releasing remnant sand washing mud freely and recycling it instead. Reusing the sand washing mud requires improving the water purification systems used in the EvoWash machine.

NUMBER OF REFERENCES	NUMBER OF FIGURES	NUMBER OF TABLES
31	4	7

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INTRODUCTION

Man is the most critical and compelling reason behind environmental changes. Considering the intimate nature of development and the environment, obtaining environmental management practices in all development programs must be a priority to prevent any harm to the resources and the environment as much as possible. One of the environmental issues affected by urban development, especially in developing countries, is indiscriminate construction leading to increased amounts of construction debris produced by the demolition and renovation of buildings (Akrami and Alipour, 2017). Iran is not an exception. Due to the rapid growth of the urban population in most cities and metropolises, enormous amounts of dirt and sewage are transferred to the Construction and Demolition (C&D) waste disposal plants daily. According to official data, in the metropolis of Tehran, the C&D waste is about six times more than household waste (Asgari *et al.,* 2017), almost equal to 40,000 tons of sand and debris. About 25% of the waste is recycled (Fig. 1). According to this report, half of this amount enters the cycle of infrastructure operations. It is used as fillers for construction projects, and the rest is turned back into sand via recycling plants (Saghafi and Hosseini Teshnizi, 2011). The rest of the waste material is stored in burial centers due to inadequate awareness or missing technologies required to recycle the waste load. In the long run, consequences such as occupying an ample space, capital accumulation, and numerous environmental pollutions will arise (Webb *et al.*, 2005). During the last two decades, widespread attention has been increasingly drawn to environmental preservation. Hence industrial activities have been impressed (Abbaspour and Mohammadi, 2020). Regarding the lack of economic capital return in the short term and municipal budget restrictions, the extraction of these wastes might not seem cost-effective at first glance (Fayyaz *et al.*, 2013), but due to the change in global approaches to the environment and regulations (Sajedi and Yavari, 2016), the number of plants actively functioning at C&D waste recycling is increasing. Given this fact, by 2016, only one sand recycling plant was present and active in Aab'Ali Landfill of Tehran, with a daily production capacity of 3300 tons. By 2021, the number of recycling plants has had increased to four fully operational plants (Tehran Waste Management Organization, 2021).

In the C&D waste recycling factories, the extracted sand is rinsed, and the remaining water is directed to the EvoWash machine. After the sludge settles at the bottom of the tank, the water overflows into the recycling tanks again. The settled sludge is transferred to the sand washing mud depot ponds through the opening valves. Although the sand washing mud ponds are large (20 x 40 meters with a depth of 6 meters), they still cannot hold the increasing amount of incoming sand washing mud. After a few days, some sand washing mud overflows from the ponds, and the material should be moved to the old pond by an excavator. In this transportation process, a part of sand washing mud is inevitably spilled on the earth's surface, gradually penetrating the underlying soil layers. The waste material entering the Aab'Ali Landfill was collected from twenty-two regions of Tehran with different physicochemical and biological characteristics from varying depths. The produced sand washing mud characteristics would vary following the type of incoming waste and the depth of sampling areas. The penetration of this remaining mud in the lower layers can change the overall texture, which can affect the ecosystem in the long run. This can affect the ecosystem in the long run. On the other hand, the release of sand washing mud and resulting aerials negatively impacts the well-being of residents around the landfill. Research also shows that sand factories have the largest share in the production of sand washing mud (Chehrehghani *et al.*, 2019). Considering the increasing accumulation of sand washing mud in the two old and new ponds of Aab'Ali Landfill and its consequences, this research has been done to study the environmental impacts of sand washing mud.

Research background

Following the requirement of using environmental impact assessment tools, the research conducted by Mateichyk *et al.* (2021) under the title of "Developing a tool for environmental impact assessment of planned activities and transport infrastructure facilities" has focused on the necessity of using a tool for environmental impact assessment, the benefits, and complications of using the Leopold matrix as a method of identifying the negative effects of services provided for the transportation infrastructure. The research acknowledges the complexity and time-

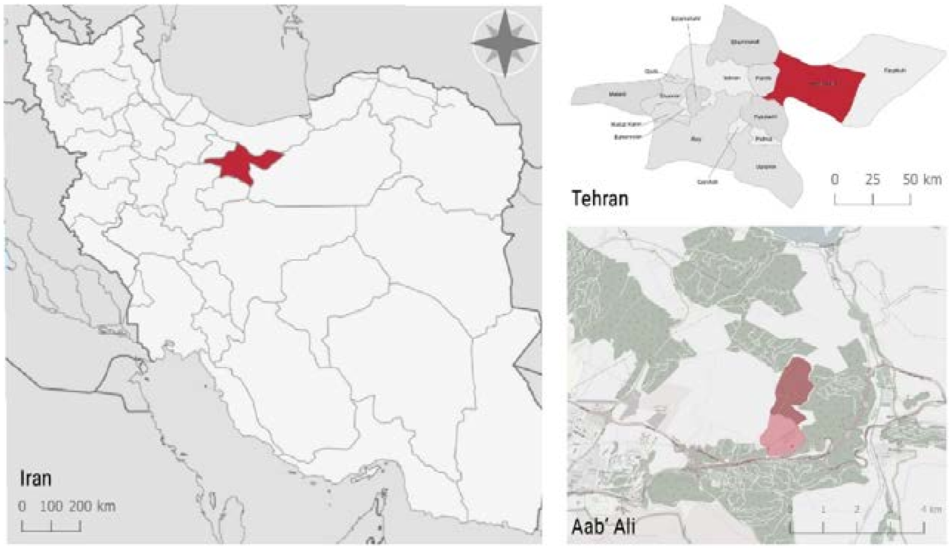

Fig. 1: Geographic location of the study area in Aab'Ali landfill in Tehran, Iran

consuming calculations of the matrix and therefore states a need for a developed and comprehensive tool for evaluation to investigate environmental effects. The researchers have used a web system in cooperation with relevant organizations to analyze matrix calculations in an urban transport project. The results of this experiment state that the use of EIA tools helps the speed and accuracy of the project to a great extent. Al-Nasrawi *et al.* (2020), in the study "Using the Leopold Matrix procedure to assess the environmental impact of pollution from drinking water projects in Karbala city, Iraq," also pointed out that after using the Leopold Matrix in the traditional way of assessing the environmental impacts of seven water projects, it was proven that the shortcomings of the evaluation are caused by the old technique and errors in the calculations. The evaluation system needs to be upgraded. Leopold's Matrix can predict the long-term impacts. Thus, it can be considered a suitable process for reducing the effects of such projects on human well-being and the environment in the future; however, the application is challenging and requires professional knowledge. Considering the complexities of Leopold matrix calculations and the type of output of this system, suggestions were made in Iran on how to improve this method. Such practices led to this tool's development under the Iranian Leopold matrix title. Zanganeh *et al.* (2021) have used this Iranian Matrix in the research entitled "Evaluation of the environmental effects of Sadr double-deck highway of Tehran on surrounding neighborhoods." This system allowed researchers to discuss more data in a shorter time in seven separate areas, including social, physical, visual, health-sanitary, economic, ecological, and safety-security. Gholamalifard *et al.* (2014) conducted research entitled "Application of rapid impact assessment matrix and Iranian Matrix (modified Leopold) in environmental impact assessment of Shahrekord solid waste landfill" using RIAM matrix and Iranian Leopold matrix to assess the environmental effects of the solid waste landfill of Shahrekord. According to the results and applied evaluation methods, the continuation of burial by the current means is unacceptable in terms of well-being preservation. The continuation of the current process would be accompanied by severe environmental damage. As for evaluating the environmental effects of industrial plants, Imani *et al.* (2019) conducted a study under the title of "Environmental impact assessment of Yasuj cement factory using iranian RIAM and Leopold Matrix," which evaluated the environmental impacts of the cement factory in Tengari village of Yasuj, via Iranian RIAM and Leopold Matrix. This study was carried out in two construction and operation stages and examined the physical, biological, socio-economic, and cultural environments. In this study, the researchers figured out that the environmental damages in the exploitation phase are related to socio-economic and cultural sectors and during construction, biological, and physical stages. Another study by Aliakbari *et al.* (2018) entitled “Evaluation of environmental effects of coal mine in northern Iran using Iranian Leopold Matrix method” has evaluated the environmental effects of coal mines as an industrial unit using the Iranian Leopold matrix. This study indicates that the crucial destructive environmental effects of coal mining in physical terms include soil pollution, erosion, and air contamination. Additionally, the main biological impacts disturbed plant and animal species density while reducing habitat quality. The results also indicate that, practically, it is impossible to eliminate the negative effects and consequences of coal mining. However, it is possible to reduce the negative effects of the Goliran coal mine through corrective measures in the form of an environmental management program, especially in the biological environment. Heidari *et al.* (2017), using Iranian Leopold Matrix in their study entitled “Evaluation of environmental effects of Zaveh cement plant using Iranian Leopold Matrix” determined that, harmful environmental impacts include soil pollution and erosion, air pollution, and noise pollution. The main adverse biological effects include disturbances of plant and animal species and reduced quality of the habitat. Comprehensive environmental management practices can significantly reduce the negative environmental impact. Ladlow (2015) investigated the environmental effects of extraction from five sand mines and its economic and social effects in research entitled “An assessment of the impact of sand mining: Unguja, Zanzibar.” The used evaluation method was based on observation and interviews with the natives of the region and local authorities. The results showed that all mines have caused the destruction of the region’s environment and altered the local ecosystem, which in turn leaves negative impacts on economic and social matters for the residents due to its damaging effects on fruit trees. The increased amount of aerials and the release of sand washing mud to a great distance from the recycling plants is an issue that sometimes causes dissatisfaction and criticism from residents nearby the sand recycling plants. Results of the research Jafari *et al.* (2013) conducted research entitled “Investigation of environmental effects of sand mines in Mazandaran province with the help of GIS” on the environmental effects of sand mines in Mazandaran province and indicated that the protected areas of Alborz, Heraz, and Rudbar take the most mining activity damage among other protected areas of the region. This research has used geographic information systems to evaluate the volume of airborne particles in different periods. Sreebha and Padmalal (2010) have published a study titled “Environmental impact assessment of sand mining from the small catchment rivers in the southwestern coast of India, using a questionnaire. The study examined the satellite maps to evaluate the environmental effects of the sand factory in southwest India. The results showed that due to the extensive negative effects of the project, no other factory should be built in the future in the same region. The conditions of the built factory should also be reconsidered. Ebadati and Fakhimi (2006) in research titled “Evaluation of the environmental effects of the establishment of industries related to clay and sand mines in the southwest of Tehran province”, using the Rapid Impact Assessment Matrix (RIAM), investigated the locations of mining industries in the southwest of Tehran and a case evaluation of the biological pollution of these mines that resulted from the extraction and the processing of minerals such as clay enters the environment. Regarding evaluating the environmental effects of industrial effluents, the study of Bagheri Tavani *et al.* (2014) titled “Investigating the effects of sand factory effluent on biological, environmental and ecological indicators of Tirum River” investigates the biological, environmental, and ecological indicators using the Kolmogorov Smirnov test for data normalization, one-way ANOVA variance test for data analysis, and Duncan’s test for project comparison. Accordingly, the results showed that the introduction of sand washing mud into the river has reduced the biodiversity and density of Macrobenthos in the research area. Chehrehgani *et al.* (2019) have conducted research entitled “Investigating the destructive effects and environmental solutions of sand harvesting from the Nazlochai River in Urmia” to investigate the destructive environmental consequences of disproportionate sand extraction from the bed of a river and sand washing mud produced during the process. The results indicated the entrance of excessive sand extraction and sand washing mud into the river bed, resulting in the river bed being unstable and loose, destroying some aquatic plants. Adverse effects involve many biological and environmental aspects. The pollution of this river has also caused a decrease in sports and tourist activities, which has caused social and economic issues for this area. Choopan and Emami (2018) have also studied the reuse of treated wastewater for agricultural usage in research entitled "Evaluation of physical, chemical and biologic properties of Torbat-heydarieh's municipal wastewater treatment plant for agricultural uses". The results of their study showed that the amount of nitrate in the wastewater is higher than the standards of the World Organization Health and Food and Agriculture Organization. It means that for the reuse of wastewater, appropriate strategies should be considered. Considering the destructive environmental effects such as ecosystem change, social, economic and developmental, biological and visual damages, health and environmental comfort problems, and changing the chemical and biological properties of water, soil, and air caused by the entry of pollutants such as TSS (Total Suspended Solid), Coliform, nitrate, sulfate, phosphate, chloride and poisonous non-organic compounds resulting from the activity of sand factories, the present research aims to identify the design and implementation stages of a sand factory in a construction landfill, using the Iranian Leopold Matrix, to evaluate the environmental effects caused by the factory's activity in the two phases of operation and implementation, as well as to examine the physical and chemical characteristics of the sand washing mud in the Aab'Ali landfill. Identifying these effects is necessary for the future development of factories in the area. The current study has been carried out in Tehran in 2021.

MATERIALS AND METHODS

Study Area

Aab'Ali processing and disposal complex is located 25 km east of Tehran, 1700 meters from Hazardera mountains, 3.5 km from Jajrud river, and 5 km from Letyan Dam (Figs. 2 and 3). Between 1977 and 1990, this complex was the landfill for Tehran's household waste. The process of landfilling caused a lot of environmental pollution due to the proximity of the site to the river and effluent infiltration into underground and surface water resources. Therefore, according to the regulations announced by the Iran Department of Environment (DOE), and the Tehran city council since 1991, this complex has been considered exclusively for depot and disposal of construction wastes produced in twenty-two areas of Tehran. The total area of this complex reaches

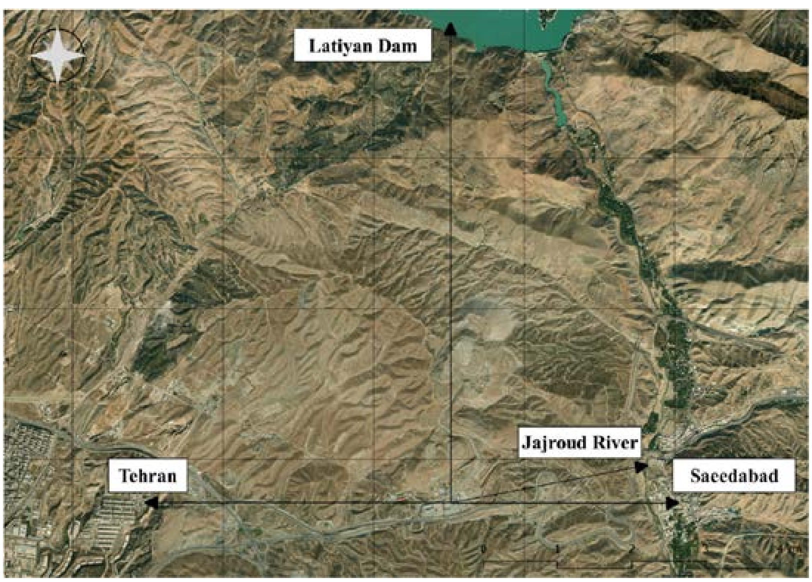

Fig. 2: The Aab'Ali landfill area and surrounding

Fig. 3: The location of the Malek Shen sand recycling factory

545 hectares, and each section is specified in various utilizations according to the type of waste entering it (Majedi Ardakani *et al.*, 2007). With the growing importance of environmental issues and the recycling of construction materials as well as the accumulation of waste in this center, after 2010, the construction and operation of the Rigsazan factory for the reuse of C&D waste took place. From 2016 to 2021, Tehran Municipality's Investment and Partnerships Organization implemented the plan to build three more factories (Tehran Waste Management Organization, 2021). In this study, the environmental effects of sand washing mud of the Malek Shan factory have been investigated.

The process of C&D waste recycling in the Aab'Ali complex is in the following stages; initially, loaded trucks transfer the residual material to the complex. Surplus objects such as pieces of bricks, wood, and glass are removed manually. Concrete blocks and boulders are transferred to be broken down by jackhammers before entering the silos. Crushers break the segments into smaller pieces. Crushed gravels are transferred via conveyor bolts, where electrical magnets remove metal particles. The remnants are sifted through triple sieves and assorted before entering the sand maker machine. The output is sieved once more and assorted into three stacks. The first stack is sent to sand washing plants and returned to the sale storage. The second stack is divided into two subsections, the first section stored as regular gardening soil and the latter sent to sand washing and EvoWash machines. The last assortment consists of exceedingly large particles and will be returned to the second stage to carry out the procedure. The remaining sand washing mud and EvoWash residues are transferred to storage ponds (Central gravel plant). Regarding the varying composition of the soil in different depths at various areas in Tehran, the texture and components would differ for every given area. Additionally, the type of construction debris and its composition in each excavation operation is different compared to other regions. Thus, the kind of materials entering Aab'Ali Landfill is diverse, which can affect the physicochemical and biological characteristics of sand washing mud produced by the factory (Tehran Waste Management Organization, 2021).

Methods

At first, the statistics and documentation regarding the EIA of sand factories have been reviewed. Then, field and laboratory observations and investigations have been done to examine sand washing mud's physical and chemical characteristics; considering the variety of its components in Aab'Ali Landfill (due to the depth differences and varying locations of the soil and debris collected in Aab'Ali), 30 samples of the mud weighing one to three kilograms were collected manually by excavators and spades. The samples were sent to an accredited laboratory to check their composition. The sampling process was carried out at different times, including pre-and post-rainfall, after sunny phases, and dried sand washing mud. The average amount of compounds in the sampled sand washing muds was analyzed to evaluate their environmental impacts. There are different methods to evaluate the impact of a project on the environment. These methods include the matrix method, completing related checklists, etc. The Leopold matrix method is a common one, initially presented in 1971 by Leopold to analyze environmental effects (Valizadeh and Shekari, 2015). This matrix was localized and modified by Makhdoom (2007) according to the country's local conditions and named the Iranian Leopold Matrix. The main advantage of this matrix is the presentation of diagrams and results of each area, as well as summarizing the project's negative (destructive) and positive (constructive) effects in two stages: implementation and exploitation. The Iranian Leopold matrix has been used by Armansabz Researchers Consulting Engineers (2019) researchers in the design and development of EIA+ software to provide appropriate charts for the evaluation report. The software evaluation results can be reviewed in five categories. The scoring process is applied in a range of +5 to -5. The number +5 indicates a positive effect (as in high efficacy or favorability), and the number -5 indicates adverse effects (as in destruction or highly unfavorable). Micro-activities with an average score between -5 and -3.1 are known as undesirable domains, and if they make up more than 50% of the project, the project is considered undesirable. Therefore, it will be rejected. Regarding environmental considerations, such projects with low scores should not be included in the implementation and operation order. On the contrary, if more than 50% of a project has scored between +3.1 and +5, it indicates the desirability and approval of the project and minor adverse effects on the environment so that it can be implemented with low concern for environmental risks. If the average score of micro-activities is not less than -3.1, and the number of columns with an average score of less than -3.1 is less than 50%, the project can be implemented; but corrective options should be considered for it. Likewise, if the average in the columns is not less than -3.1 and the number of rows with a standard lower than -3.1 is less than 50%, the implementation of the project should be accompanied by an improvement plan. Finally, suppose the average number of scores in rows and columns is smaller than 3.1 and consists of less than half of the total number of middle rows and columns. In that case, the project will still be feasible, but modification options should be proposed and implemented under improvement (Makhdoom, 2007).

RESULTS AND DISCUSSION

Two plans are examined to evaluate the environmental effects of the sand factory located in the Aab'Ali Landfill. The first plan prevents the implementation of the factory construction project, and the second option is to implement the factory construction plan. For the first plan, the environmental effects of the exploitation phase are considered, and in the second plan, the two phases of construction and exploitation are considered. The environmental effects of the projects have been categorized and ranked in four categories, including physicochemical, biological, socio-cultural, and economic-technical areas. Initially, the first option (i.e., no implementation of the factory construction plan) is examined. In this case, the C&D waste brought to the landfill is stored, and no operations are carried out for recycling. The micro-activity (not operating the construction waste recycling plant, no sale of products, and no employment) and 21 environmental parameters are considered at this stage. In the following, the ranking tables and the summary of the environmental impact assessment analysis for this option are presented (Tables 1 and 2).

According to the analysis results, the highest average negative effect of the plan in case of no project implementation is related to the economic-technical area. The highest number of positive outcomes is associated with the physicochemical area, which will lead to harmful results in the long run. It should be considered that if the project is not implemented, a large amount of soil and garbage will be accumulated. In the medium term, the landfills will not have the capacity for more waste material. The lack of space will lead to increased landfill establishments in various areas, intensifying

Table 1: Ranking of environmental indicators for no implementation plan at operational phase

Area	Substandard	No operation of construction waste recycling plant	No product sale	No employment	Total number of results	Algebraic sum of results	Average results	Number of positive results	Number of negative results
physicochemical	soil quality	-3			1	-3	-3	0	1
	Soil stability	-3			1	-3	-3	0	1
	soil erosion	-3			1	-3	-3	0	1
	air quality	-2			1	-2	-2	0	1
	Surface water quality	-3			1	-3	-3	0	1
	The amount of underground water	2			1	2	2	1	0
	noise status	3			1	3	3	1	0
	Residual status	-4			1	-4	-4	0	1
	Hazardous waste status	-4			1	-4	-4	0	1
	Landscape status	-4			1	-4	-4	0	1
	Effluent status	3			1	3	3	1	0
Biological	Vegetation	-2			1	-2	-2	0	1
	Wildlife	-2			1	-2	-2	0	1
Socio-cultural	Incoming migration			-3	1	-3	-3	0	1
	Preventing migration outside the region			-3	1	-3	-3	0	1
	Development plans in the region		-3		1	-3	-3	0	1
	Social welfare facilities and services		-3		1	-3	-3	0	1
Economic-technical	Consumption of energy resources	3			1	3	3	1	0
	Land use	2			1	2	2	1	0
	Increasing income and improving the standard of living			-3	1	-3	-3	0	1
	Effect on economic activities		-3		1	-3	-3	0	1
	The value of land, real estate, and properties		-3	-3	2	-6	-3	0	2
Impacts	Total	15	4	4					
	Sum	-17	-21	-21					
	Average	-1	-3	-3					
	The number of positive effects	5	0	0					
	Number of adverse effects	10	4	4					

environmental and economic consequences. Still, it should be accompanied by corrective decisions to compensate for economic, social, and environmental damages and an improvement plan to dispose appropriately of C&D waste. The evaluation results using Leopold's matrix method show that this option is possible. The second option is the implementation of the construction plan for the sand production plant to recycle the C&D waste in the landfill. Such a project should be carried out in two construction phases

Table 2: Summary of the entire project for no implementation of the plan, operation phase

Area	Average impacts of the total project	Number of positive effects of the whole project	Number of adverse effects of the entire project
Physicochemical	-0.55	3	8
Biological	-0.67	0	2
Sociocultural	-2	0	4
Economic -technical	-1.17	2	4

Table 3: Summary of the entire project of implementing the factory construction plan, construction phase

Area	Average effects of the total project	Number of positive effects of the whole project	Number of adverse effects of the entire project
Physicochemical	-1.63	6	38
Biological	-0.07	4	2
Socio-cultural	-0.74	4	5
Economic- technical	-0.81	4	6

with seven micro-activities and 25 environmental parameters. The operation phase, with 13 micro-activities and 23 environmental parameters, was examined and evaluated by The Iranian Leopold matrix. In the construction phase, micro-activities of cleaning, land leveling and land preparation/ energy supply (water, electricity, etc.), excavation and embankment, changing the drainage system and sand washing mud storage pond bedding operations, concreting operations and heavy structures, workshop equipment and the construction of ancillary facilities and welding or transportation of materials, equipment and employees and the establishment of green space were evaluated. Since the factory investigated in this research is currently under building and operation, the results of this section are summarized below. According to the matrix, the project is fully approved; since there is no rank lower than -3.1 in the average evaluation of its effects (Table 3).

Regarding the results, it's evident that the construction of a factory has more scores compared to the case where no construction is carried out. This outcome indicates that the construction of a sand factory in Aab'Ali Landfill had many positive effects compared to when there was no factory. But like any other project, the construction of the factory also has a different impact on its surrounding environment, which is further evaluated in the operation phase. In the operation phase, according to the current activity of the factory, the micro-activities consisting of transporting waste to the factory by truck, manually separating excess materials (bricks, wood, etc.), turning concrete pieces and large boulders into smaller pieces by jackhammer machine and transferring them to the jaw crusher, separating metallic compounds by electric magnet from the conveyor belt, separating lightweight waste materials such as plastic with an extraordinary geyser from the conveyor belt, transferring crushed materials to the sand maker machine and re-shredding the aggregates, transferring fine sums to the sand making machine followed by sieving operations, re-transferring large materials to the secondary circuit to carry out re-operations, washing the sand through sand washing machine, washing fine sand through the EvoWash machine, transferring the manufactured products to the depot for sales, transferring the waste material and effluents left from washing machines to the storage basin, and then returning the water to the processing devices, maintaining the green space, and hiring and transportation of employees were discussed and evaluated (Table 4).

According to Table 6, in the exploitation phase, the highest number of negative effects and the highest average of negative effects are related to the physicochemical area. The results of the matrix indicated that the three micro-activities of washing the sand through a sand washing machine, passing fine sand through the EvoWash machine (-3.6), converting concrete pieces and large boulders into smaller pieces by a jackhammer, and transferring to a jaw crusher (-2.8) and transferring the sand washing

Table 4: Ranking of environmental indicators of project implementation, exploitation phase

Area	Substandard	Transportation of waste	Manually separating	Conversion into smaller pieces	Separating lightweight waste	re-crushing	Transferring to the sand-making machine	Re-transfer of oversized materials to re-operation	Washing with sand washing and the EvoWash machine	transferring the products to the depot for sales	transferring the waste material and effluents left from washing	returning the water to the processing devices	Green space maintenance	Recruitment and transportation of employees	Total number of results	Algebraic sum of results	Average results	Number of positive results	Number of negative results
Physico-chemical	soil quality	-1	-2	-2	-2	-2	-2	-2	-2	-3		-4	2	-1	12	-21	-1.8	1	11
	Soil stability	-2										-3	2	-1	4	-4	-1	1	3
	soil erosion	-2										-3	2	1	4	-2	-0.5	2	2
	air quality	-3		-3			-2	-2	-2		-2		2	-1	8	-13	-1.6	1	7
	Surface water quality	-3	-2	-2				-2	-2						5	-11	-2.2	0	5
	The amount of underground water					-2				-4		1			3	-5	-1.7	1	2
	Noise status	-4		-4	-2	-2	-2	-3	-2	-4	-2	-3	2	-1	12	-27	-2.2	1	11
	Residual material status		-3		-2	-2				-4		-4		-1	6	-16	-2.7	0	6
	Hazardous waste status									-3		-4			2	-7	-3.5	0	2
	Landscape status	-2	-2									-3	2		4	-5	-1.2	1	3
	Effluent status					-2				-4		-1			3	-7	-2.3	0	3
Biological	vegetation												3		1	3	3	1	0
	wildlife												3		1	3	3	1	0
	Habitat												2		1	2	2	1	0
Socio-cultural	Incoming migration													4	1	4	4	1	0
	Preventing migration outside the region													4	1	4	4	1	0
	Development plans in the region										5				1	5	5	1	0
	Transportation and traffic	-4	-2		-1						-3			-1	5	-11	-2.2	0	5
	Social welfare facilities and services										4				1	4	4	1	0
	Consumption of energy resources	-2		-3	-2	-2	-2	-2	-2	-3	-3	-3		-1	11	-25	-2.3	0	11
Economic-technical	Increasing income and improving the standard of living													4	1	4	4	1	0
	Effect on economic activities										4				1	4	4	1	0

Continued Table 4: Ranking of environmental indicators of project implementation, exploitation phase

Area	Substandard	Transportation of waste	Manually separating	Conversion into smaller pieces	Separating lightweight waste	re-crushing	Transferring to the sand-making machine	Re-transfer of oversized materials to re-operation	Washing with sand washing and the EvoWash machine	transferring the products to the depot for sales	transferring the waste material and effluents left from washing	returning the water to the processing devices	Green space maintenance	Recruitment and transportation of employees	Total number of results	Algebraic sum of results	Average results	Number of positive results	Number of negative results
	The value of land, real estate and properties										4				1	4	4	1	0
	Total	9	5	5	5	6	4	5	5	7	8	10	9	11					
Impacts	Sum	-23	-11	-14	-9	-12	-8	-11	-10	-25	7	-27	20	6					
	Average	-2.6	-2.2	-2.8	-1.8	-2	-2	-2.2	-2	-3.6	0.9	-2.7	2.2	0.5					
	Total positive effects	0	0	0	0	0	0	0	0	0	4	1	9	4					
	Total negative effects	9	5	5	5	6	4	5	5	7	4	9	0	7					

Table 5: The average environmental effects of project implementation, operation phase

Area	Transportation of waste	Manually separating	Conversion into smaller pieces	Separating lightweight waste	re-crushing	Transferring to the sand-making machine	Re-transfer of oversized materials to re-operation	Washing with sandwashing and the EvoWash machine	transferring the products to the depot for sales	transferring the waste material and effluents left from washing machines to the storage basin	returning the water to the processing devices	Green space maintenance	Recruitment and transportation of employees
Physicochemical	-2.43	-2.25	-2.75	-2	-2	-2	-2.25	-2	-3.67	-2	-2.67	2	-0.67
Biological	0	0	0	0	0	0	0	0	0	0	0	2.67	0
Sociocultural	-4	-2	0	-1	0	0	0	0	0	2	0	0	2.33
Economic - technical	-2	0	-3	-2	-2	-2	-2	-2	-3	1.67	-3	0	1.5

mud produced by the washing machine to the storage pond (-2.7) were stated the most negative effects. Consequently, the three micro-activities of using for the maintenance of green space (+2.2), selling products (+0.9), and hiring employees (+0.5), were the highest positive effects on the environment (Tables 5 and 6).

Since the average number of rows and columns ranking lower than -3.1 consists of less than 50% of the total average number of rows and columns, the implementation of the project is approved by providing correction options and under the condition of improvement. In addition, the results determined that the implementation plan of the sand factory in the Aab'Ali Landfill was positive and beneficial. However, similar to many other projects, the present research encounters shortcomings that cause environmental damage. According to the matrix

Table 6: Summary of the implementation of the factory construction plan, operation phase

Area	Average effects of the entire project	Number of positive effects of the whole project	Number of adverse effects of the entire project
Physicochemical	-1.9	8	55
Biological	0.21	3	0
Sociocultural	-0.21	4	5
Economic -technical	-1.37	3	11

Fig. 4: The sight of the unmanaged sand washing mud in the study area

results, the largest share related to the stage of sand washing and the release of sand washing mud resulting from this process equals -3.6. Considering the damage caused to the landscape and ecosystem of the region, and the harm it can cause to the natural environment, human, animal, and plant health, the management of sand washing mud left from this operation is the most significant step in improving the project (Fig. 4). The management of sand washing mud under investigation can reduce the short-term, medium-term, and long-term environmental harms of sand washing mud in the region and help restore the region's ecosystem. This process will also improve air quality due to the reduction of fine dust, building a reliable soil base for future developments, preventing soil erosion, reviving underground water and ensuring their health, and improving vegetation and agricultural operations by preventing sand washing mud from contaminating the area; therefore, preventing soil salinization in the long run. This issue will also help change the overall ecosystem and save manpower, lowering expenses and consuming less time.

The first step in the production management of sand washing mud in the investigated factory is to study the physical and chemical properties of this material. Such considerations pave the way to determine its nature and estimate the amount of pollution and make it clear how dangerous it is for the environment. Considering the difference in the number of elements present in every sampling of sand washing mud, thirty samples (1-3 kg) of sand washing mud were obtained in two different weather conditions (15 samples on a dry and sunny day and 15 samples after the rain), and from various locations and depths of the pond. Sand washing mud depots were collected and sent to the laboratory. The average concentration of multiple elements in the sand washing mud samples has been presented in the following table (Table 7).

Based on Iran DOE (2021), the concentration of magnesium, copper, zinc, nickel, chromium, and lead, as well as chemical characteristics of sand washing mud (i.e., pH), and compounds such as total nitrogen, phosphorus, chloride, soluble components, nitrate, bicarbonate, and ammonia, were lower than the regulated limit. However, the concentration of elements such as calcium, cadmium, potassium, sodium, iron, and arsenic, plus the nitrite and electrical conductivity of sand washing mud, were higher than the allowed amount. On the other hand, the differences in the amount of mineral content present in samples from the inlet pond and the old pond indicate that in the case of accumulation and the passage of time, some elements are reduced by natural purification, but each collection increases some. Considering such

Table 7: The average concentration of various elements in the sand washing mud samples obtained from the old and new ponds in Aab'Ali Landfill (Ahyaei and Behbahanizadeh, 1993)

Row	Elements	Symbol	Unit	Sand washing mud of the entrance pond	Sand washing mud of the former pond	Difference in case of accumulation	Standard thresholds (Iran DOE, 2021)	Assessment method
1	Calcium	Ca	mg/kg	356	280	Decrease	200	F.P.M
2	Magnesium	Mg	mg/kg	25	29	Increase	100	F.P.M
3	Lead	Pb	mg/kg	26	24	Decrease	50	St. M. 3110-B
4	Cadmium	Cd	mg/kg	2.5>	2.5>	-	1	St. M. 3110-B
5	Potassium	K	mg/kg	6.77	5.78	Decrease	6	F.P.M
6	Soil pH	PH	-	7.40	7.46	Increase	6.5 - 8	St. M. 4500-H+ B
7	Electrical conductivity	EC	Ds/m	2959.86	2648.29	Decrease	500-700	St. M. 2510
8	Total Nitrogen	NT	%	126	197	Increase	2<	*
10	Sodium	Na	mg/kg	218.06	205.89	Decrease	8	F.P.M
11	Total phosphorus	PT	mg/kg	0.2>	0.2>	-	6	*
15	Chloride	CL	mg/kg	210	203	Decrease	600	F.P.M
16	Soluble minerals	TDS	mg/kg	1585.13	-	-	500-2000	*
17	Nitrite	NO2	mg/kg	9.6	10	Increase	3>	*
18	Nitrate	NO3	mg/kg	30	18	Decrease	50>	*
20	Bicarbonate	HCO3	mg/kg	64	77	Increase	170	St. M. 4B-CO-2D
21	Alkalinity	TAC	mg/kg	207	-	-	270	St. M. 2320-B
22	Ammonia	NH3	mg/kg	6.8	17	Increase	100	*
25	Copper	CU	mg/kg	28.20	28.95	Increase	100	St. M. 3110-B
27	Iron	Fe	mg/kg	49320	48560	Decrease	2000	St. M. 3110-B
28	Zinc	Zn	mg/kg	89.19	88.61	Decrease	200	St. M. 3110-B
29	Arsenic	As	mg/kg	25.22	21.62	Decrease	18	St. M. 3110-B
30	Nickle	Ni	mg/kg	37.9	37.75	Decrease	50	St. M. 3110-B
32	Chromium	Cr	mg/kg	26.40	24.55	Decrease	100	St. M. 3110-B
33	Mercury	Hg	mg/kg	0.54	1.08	Increase	10	St. M. 3110-B

* Description of soil decomposition methods: Publication No. 893 of the Ministry of Agricultural

procedures, the proposed options for organizing sand washing mud at this center should be presented while considering the varying nature of sand washing mud. On the other hand, this indicates that natural refinement cannot be expected after the components are released; by comparing the laboratory results of sand washing mud, it can be concluded that the gradual release has increased the concentration of elements such as magnesium and copper while reducing others including sodium and lead. Since 25% of the factory space is specified for green space and the location of the factory is 3.5 km from the Jajrud River and 5 km from the Letyan Dam, increasing the amount of copper in the soil can disturb photosynthesis, plant growth, and plant reproduction processes, while reducing the outer surface area of the thylakoid (Jorge *et al.*, 2005) as well as the reduction and destruction of aquatic plants (Chehrehgani *et al.*, 2019). This also does not affect the economy and the tourism aspect of the surrounding tourist areas (Chehrehgani *et al.*, 2019). The amount of nitrite in the sand washing mud of the factory is higher than the regulated limit. The results of Choopan and Emami (2018) are also consistent with the current research regarding high nitrate levels. Nitrates are the main sources of pollution because they can travel long distances in the soil and bring many risks to the use of underground water sources. Nitrogenous compounds such as nitrate are among the polluting factors of underground water resources, which can be intensified when using sand washing mud, and recycled water. Sand washing mud and wastewater are rich in nutrients and carry pathogenic microorganisms. Thus, the utilization of such components will accelerate and intensify the phenomenon of eutrophication (Zhang *et al.*, 2020). In addition, the concentration of heavy elements such as cadmium and arsenic in the sand washing mud of the factory was higher than the regulated limit. Meanwhile, one of the significant problems in using sand washing mud, and returned water is the accumulation of heavy metals in the soil which gradually contaminate the plants. These elements do not have much effect on the plant in the short term but will slowly accumulate in the plant tissues, leading to consumption by humans and animals. Thereby, the elements are transferred to other living organisms and cause damage. Most of these metals are deposited in the surface layer of the soil after penetration and turn into insoluble compounds that the plant cannot absorb. During tillage operations in the following years, these substances are transferred to the root area and become available to the plant. Therefore, the accumulation of sand washing mud and its entry into return water in the agricultural lands of south Tehran has caused a higher concentration of heavy metals in the soil and crops produced in these areas (Makari Yamchi and Gheshlaghi, 2015). Comparing the current research results and previous studies in the field of evaluating the environmental effects of industrial effluents, it can be concluded that limitations in sampling and accessing the pond are hindering investigation purposes. Hence, the present study is the first research conducted on sand washing mud in Tehran. This substance is produced in the Aab'Ali Landfill, carried out in cooperation with the Malek Shen sand factory. On the other hand, the EvoWash machine has been used for the first time in Iran and in this landfill. Therefore, there is less similarity between articles, laboratory results, and gathering sample methods. This is the major difference between this study and similar studies (Heidari *et al.*, 2017; Gholamalifard *et al.*, 2014; Jafari *et al.*, 2013). Another main issue of the present study is using recycling construction debris to produce sand, which causes other elements to be included in the production process. However, if the factory uses natural or river stones, the percentage of heavy and dangerous elements will generally be much lower. This difference causes also various texture and appearance characteristics between sand washing mud (which includes sand, clay and loam) and the sand factory effluent. The mud is denser, sticky and can keep humidity for a longer time. Its weight and stickiness make it more difficult to gather it from the site; because of that, sampling should be done with an excavator (Bagheri Tavani *et al.* 2014; Chehrehgani *et al.*, 2019). Assessing the environmental impacts can be conducted with different evaluation methods (Imani *et al.*, 2019; Ebadati and Fakhimi, 2006); EIA+ has been used in this research as a more recent software in Iran's research platform, which is a kind of localization of Leopold's Matrix and provides more accurate evaluation results.

CONCLUSION

Although recycling and reusing soil and construction debris brings many advantages, it can also cause harm to the human, animal, and plant environment. With the increase in awareness about the importance of examining plans and research before implementation and predicting solutions to deal with the adverse environmental effects of a project, it is possible to adjust these damages. One activity that can harm the environment in the direction of construction waste recycling is constructing a sand factory. Although these factories prevent the accumulation of sewage in an area, have economic efficiency, and prevent visual, physical, and chemical damage, they can also cause damage to the environment. In this article, by examining the sand factory in Aab'Ali Landfill of Tehran, the performance of this factory was investigated concerning its environmental effects. Since, at the time of this factory's construction, investigating its environmental impacts in the future was not very important, this factory was built and operated without an initial evaluation. The purpose of the investigation of this factory was to discuss and investigate its environmental effects according to the current case study, considering the development plan of this factory and the construction of other factories in this area. This review is proposed in two phases' implementation and exploitation. The research results show that in both phases, the construction of the factory was doable, but preparations were needed. Among the significant environmental damages of this factory, we should mention the effluent from the sand washing stage, which has harmful elements to water, soil, and air and is left in the landfill without any management.

SUGGESTIONS

Considering the destructive effects of sand washing mud in the exploitation phase of the sand recycling plant construction project in Tehran's Aab'Ali center, it is necessary to consider proper measures to manage and organize the produced sand washing mud.

The following arrangements are suggested to organize and adjust the environmental damages of the effluents of these factories: 1) Using a pressing filter to enter more water into the reuse cycle and minimize the amount of sand washing mud; 2) Using a nebulizer to prevent the spread of dust due to the movement of machinery and unloading; 3) covering the surface of trucks and loading trucks in the allowed capacity; 4) Creating a boundary around the catchment area of the Jajrud River to prevent possible contamination; 5) Creation of diversion systems to control floods entering the pond and prevent overflow.

AUTHOR CONTRIBUTIONS

S. Salehi performed the literature review, compiled the data, analyzed and interpreted the data, and prepared the manuscript text and edition. F. Gholamreza Fahimi, M. Kiadaliri, A. Tavana, and K. Saeb reviewed the manuscript and gave constructive suggestions.

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CONFLICT OF INTEREST

The authors declare no potential conflict of interest regarding the publication of this work. 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 witnessed by the authors.

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PUBLISHER'S NOTE

ABBREVIATIONS (NOMENCLATURE)

As	Arsenic
C&D	Construction and Demolition
Ca	Calcium
Cd	Cadmium
CL	Chloride
Cr	Chromium
CU	Copper
DOE	Department of Environment
EC	Electrical conductivity
Fe	Iron
HCO3	Bicarbonate
Hg	Mercury
K	Potassium
Mg	Magnesium
Na	Sodium
NH3	Ammonia
Ni	Nickle
NO2	Nitrite
NO3	Nitrate
NT	Total Nitrogen
Pb	Lead
PH	Soil pH
PT	Total phosphorus
TAC	Alkalinity
TDS	Soluble minerals
Zn	Zinc

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