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Invasion of Parthenium hysterophorus L. across land use types in Kirtipur Municipality

K.C. Upendra[1,*], S. Bharat[2]

[1]*Health Coordination Division, Ministry of Health and Population, Ramshahpath, Kathmandu, Nepal*

[2]*Central Department of Botany, Ecology, Tribhuvan University, Kirtipur, Kathmandu, Nepal*

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ABSTRACT

Parthenium hysterophorus, an invasive alien weed, is spreading rapidly across various land uses in Nepal. To understand how Parthenium is spreading across land uses at local scale, occurrence of this weed was recorded and its' coverage in percent estimated along trails and road network at every 100 meter distance in Kirtipur Municipality of Kathmandu valley. In addition, vegetation sampling was done in waste land, road side, tree plantation, and abandoned agriculture land where Parthenium cover was greater than 25 percent. Peoples' perception about the problem of Parthenium was studied by interviewing 60 respondents using purposive sampling method. Parthenium was present in 15 percent of the surveyed locations and it was more common in urban area than in peri-urban. Peri-urban areas are those areas which are immediately adjacent to a city or urban area. It was frequently found in the waste land, road side, tree plantation, abandoned agriculture land, shrub land, grass land, settlement areas and play ground. In active agriculture land its invasion was negligible. Most of the people were not aware about the negative impact of Parthenium but 8 percent of them reported skin allergies and dermatitis due to regular contact with Parthenium. Therefore, public education can help to prevent spread of Parthenium from urban to peri-urban areas

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INTRODUCTION

Invasive alien species are recognized as one of the major threats to native biodiversity and ecosystems (Callaway and Ridenour, 2004). Their impacts on native species result directly from predation and competition for resource such as food and breeding sites as well as indirectly by altering habitat and modify hydrology, nutrient cycling and other ecosystem processes; these impacts dramatically change the ecosystem both positively and negatively (Mitiku, 2008). In the future invasive alien plant species will expand towards the high elevation mountainous region (Shrestha and Shrestha, 2019). *Parthenium hysterophorus* L. (Family *Asteraceae,* here after referred as *Parthenium*), a native of Central and South America, is a noxious weed of global significance currently reported from 34 counties in its introduced range (Adkins and Shabbir, 2014, Bajwa, *et al*., 2016). It is an annual (or, under certain conditions, a short-lived perennial) weed

*Corresponding Author:
Email: *kc_upen@hotmail.com*
Phone: 014250845
Fax: 014250842

with an erect and much-branched growth habit. It poses a serious health risk, particularly to the urban populations as it moves into new areas (Javaid and Riaz, 2007). *Parthenium* invasion is a global problem (Rai, 2015) which displaces native plant species of the ecosystem (Wubneh, 2019) and causes serious threat on biodiversity (Akter and Juberi, 2009). The rapid spread of *Parthenium* would be a bigger risk to the sustainable production of many crops (Gnanavel, 2013). The weed is able to colonize new areas rapidly by means of rapid growth and relatively high numbers of seeds disperse *via* vehicles, water, wind, animals, farm machinery and agriculture products (Mack and Lansdale, 2001). The seeds can be transferred to the urban green spaces and parks and damage the landscape in the urban areas. Disturbed habitats, such as roadsides and railway tracks, stockyards, around buildings and fallow agricultural lands, are particularly suitable for *Parthenium* due to a lack of interspecies competition (McConnachie, *et al*., 2010). Generally animals do not eat *Parthenium* and thus the plant spreads very rapidly (Riaz and Javaid, 2012). In Nepal, *Parthenium* is currently a dominant species growing along road verges and in major urban areas across diverse land use types such as grass-lands, fallow lands, abandoned agricultural lands and within some crops (Shrestha, *et al*., 2015). *Parthenium* is the most recent invader in Kathmandu valley in Nepal and appears to be potentially most harmful to native flora, animals and human health (Maharjan, *et al*., 2007). In this study, spatial distribution map of *Parthenium* were prepared in Kirtipur Municipality, and compared growth and abundance of *Parthenium* across various land-use types. The findings reported in this communication will be helpful for the management of this weed. This study has been carried out in Kirtipur Municipality, Kathmandu Province, Nepal in 2013.

MATERIALS AND METHODS

Study area

The study was carried out in Kirtipur Municipality (27˚ 38' 30" to 27˚ 41' 30" E longitude and 85˚ 13' and 85˚ 19' N latitudes; elevation: 1284 to 1524 m above mean sea level), where most of the lands such as waste lands, roadside vegetation, fallow land, etc. have been invaded by *Parthenium*. The Municipality is a part of Kathmandu valley and lies in the central middle hills region of Nepal. The general decline of elevation is from south-west to north-east (Fig. 1).

The Municipality is bordered by the Kathmandu

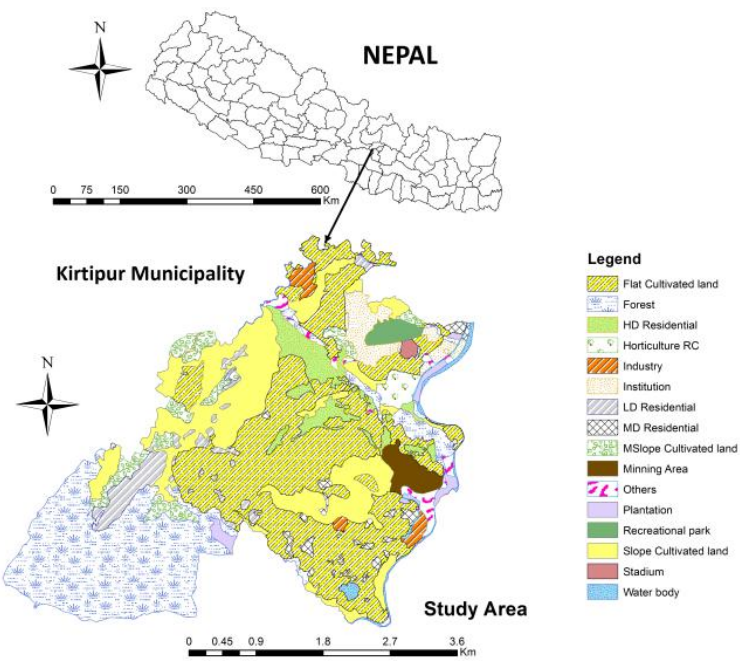

Fig. 1: Geographic location of the study area in land use types of Kirtipur Municipality, Nepal

Metropolitan City to the north, Bagmati River to the east, Chandragiri Municipality in the west and Dakchinnkali Municipality in the south. The municipality has 10 wards and the total area is 14.76 sq km. Due to its proximity to the city and the major highway, the area has been rapidly urbanizing in recent decade.

Data sources

The topographic map (scale 1:50000) was obtained from the Department of Survey, Government of Nepal (GoN). The map was in Modified Transverse Mercator projection with elevations referenced to the Everest 1830 spheroid. Digital land use map of Kirtipur Municipality (2003) was obtained from International Centre for Integrated Mountain Development (ICIMOD), Lalitpur, Nepal (ICIMOD, 2003).

Spatial distribution of Parthenium

Since vehicle movement has been considered as the major agent of *Parthenium* dispersal in Nepal (Shrestha, *et al.,* 2015), road network of the study area was used as reference for the distribution mapping. The occurrence of *Parthenium* was recorded and coverage (%) estimated visually in every 100 m distance. In every 100 m distance 20 m × 20 m (Alder and Synnott, 1992) plot was defined on either sides of the road within 50 m distance from the center of the road. At each plot the presence/ absence of the *Parthenium*, its coverage (categorized into cover classes as absent, <10%, 10-50% and 50-100%), and the GPS (Global Positioning System) coordinates (latitude, longitude) were recorded along with land-use type. The GPS coordinates were plotted on digital land use map using on-screen digitizing in ArcGIS; geographic information system 9.3 software.

Vegetation sampling

Vegetation sampling was conducted by using transect method. Four types of land uses having *Parthenium* coverage >25% were selected for sampling i.e. waste land, tree plantation, road side vegetation, and abandoned agriculture land. In each sampling site five transects were defined nearly in equal distance; in each transect two quadrats (1 m × 1 m) were located randomly. The common species found in plantation were *Callistemon viminalis* (Sol. ex Gaertn.) G.Don*, Lagerstroemia indica* L.*, Cinnamomum camphora* (L.) J.Presl, *Grevillea robusta* A.Cunn. Ex R.Br. *Pinus roxburghii* Sarg., *Cupressus torulosa* D. Don. and *Morus alb* L.. For waste land and plantation, three sites were selected for each land-use type and 10 quadrats were sampled in each site. For road side and abandoned agriculture land, only two sites were selected for each due to less availability of suitable sampling sites within which 15 quadrats were sampled in each site. Altogether 120 quadrats were sampled to determine plant species richness, and *Parthenium* coverage (%), height and density. In each quadrat all the individuals of *Parthenium* were counted. Heights of the tallest five individuals were measured and mean height was calculated. *Parthenium* coverage (%) in each quadrat was estimated visually.

Plant collection and identification

All the plant species rooted in sampling plot were collected to prepare herbarium. They were compared with specimens at Tribhuvan University Central Herbarium (TUCH) for identification. Plant taxonomist from the Central Department of Botany, Tribhuvan University, and Kathmandu also helped in plant identification. Standard references such as Malla, *et al.,* (1986) and Grierson, (2001) were used for identification. The nomenclature follows Press, *et al.,* (2000).

Peoples' Perception

Peoples' perception about *Parthenium* problem was assessed by interviewing a total of 60 respondents using purposive sampling method. The interview was targeted for farmers, gardeners and common people throughout the study area. Farmers working in agriculture land, animal herders, gardeners working in road side and common people near the sampling sites were interviewed. Among the 60 respondents 20 farmers were interviewed from Taudaha to Sundarighat area, 20 gardeners were interviewed within Tribhhuvan University Campus area, and 20 common people were interviewed from Naya Bazar, Tyanglaphat and Bhatkepati area.

Data analysis

The geographic coordinates of the occurrence locations were used to prepare spatial distribution map of *Parthenium* using ArcGIS 9.3. The data of vegetation sampling were used to calculate species richness, *Parthenium* cover, height and density as Eq. 1.

Plant species richness = the total number of flowering plant species in each quadrat.

Coverage (%) = the area covered by the *Parthenium* in each quadrat.

$$Density\left(\frac{stem}{m^2}\right) = \frac{\text{Total number of individuals of species in all sampling unit}}{\text{Total number of quadrats sampled} \times \text{area of quadrat}} \quad (1)$$

The mean of *Parthenium* density, cover, species richness and height were compared by one way ANOVA followed by Duncan homogeneity test using SPSS (Statistical Package for Social Sciences) version 16.

RESULTS AND DISCUSSION

Spatial distribution

Altogether 2034 plots were surveyed. Among them, *Parthenium* was present in 15% (303) plots. Only 2.31% of the total plots surveyed had *Parthenium* cover >50% (Fig. 2A). The frequency of plots with *Parthenium* varied with land-use types; it was the highest in wasteland (8.46%) and the lowest in grass land (0.49%) (Fig. 2B). A wasteland being completely covered by *Parthenium* was found at Sundharighat. This is also the site where waste from surrounding area was dumped. This might have led to high concentration of seeds of *Parthenium*. High abundance of *Parthenium* was also reported from western part of Chitwan valley (Bhusal, *et al.,* 2014). In active agriculture land, the invasion of *Parthenium* was negligible. Gebeyehu, (2008) and Shrestha, (2011) also reported low *Parthenium* invasion in cultivated agriculture lands, probably because of the regular weeding. The main source of introduction of *Parthenium* in Kirtipur municipality might be possibly from the high vehicular pressure. As the Hetauda-Kathmandu highway passes along Kirtipur municipality where hundreds of vehicles moves daily. In the tier of these vehicles, *Parthenium* seeds get attached and thus spread. Gebeyehu, (2008) has reported that vehicles spread the weed. Singh, *et al.,* (2004) mentioned that transportation system being main source for the distribution of *Parthenium*.

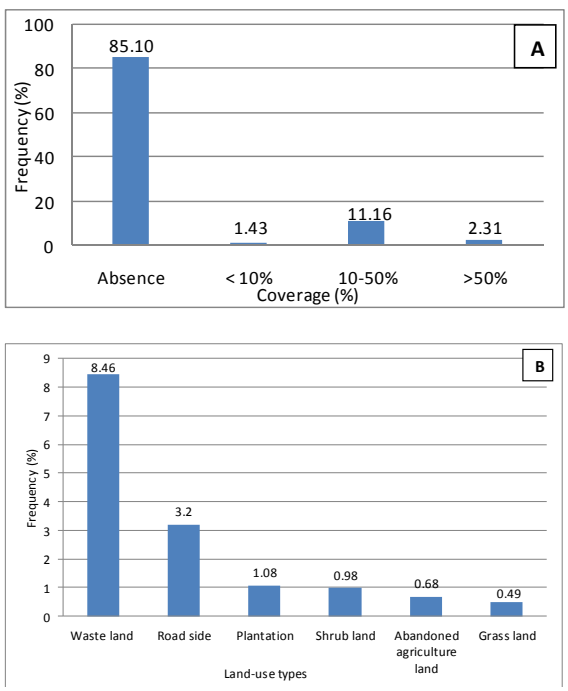

Fig. 2: (A) Occurrence of *Parthenium* in Kirtipur Municipality; (B) Occurrence of *Parthenium* across land use types in Kirtipur Municipality

Among the plots with *Parthenium* (303), 94% lied in urban area. This indicates the high propagule pressure of *Parthenium* as well as suitable habitats for the weed in the urban areas. In the present study, the urban area lies in North-east part where there is road network and residential area while peri-urban area lies in South-west part where forest and agriculture land are the dominant land-use types (Fig. 3). This result also indicated that *Parthenium* was spreading from urban to peri-urban area. A similar pattern of dispersal of *Parthenium* has been also reported by Karki, (2009) and Shrestha, (2011) in different parts of Nepal.

Parthenium across land use types

From the present field observation in Kirtipur it was found that *Parthenium* was generally found in the waste land, road side, tree plantation, abandoned agriculture land, grass land, shrub land, adjoining settlement area and play ground. There was significant difference ($P<0.001$) in *Parthenium* density across land use types with the highest density in the waste land (Fig. 4). Dominance of *Parthenium* in waste land has been also reported by Karki, (2009) in two cities (Hetuada and Bharatpur) of central Nepal, by (Gebeyehu, 2008) in Woreda of Ethiopia and in Islamabad of Pakistan (Shabbir and Bajwa, 2006). High abundance of *Parthenium* in the waste land could be due to frequent disturbance leading to removal of biomass of other plants, and high propagule pressure

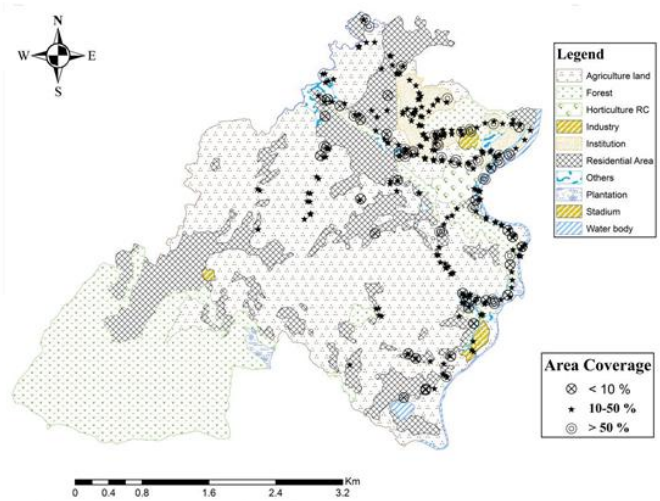

Fig. 3: Spatial distribution of *Parthenium* in Kirtipur Municipality

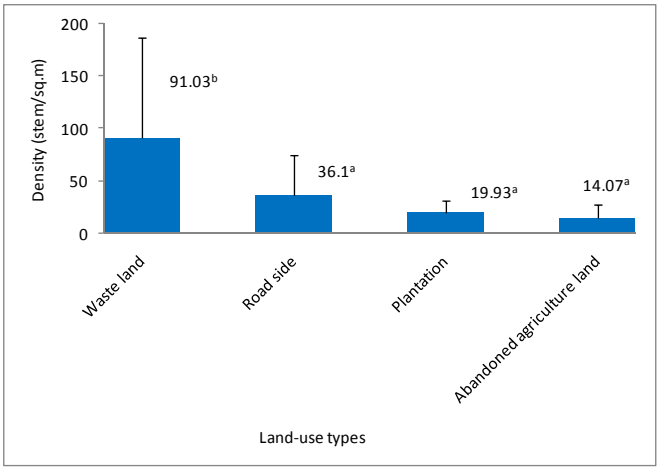

Fig. 4: Density of *Parthenium* in different land-use types. The mean values were compared by ANOVA ($F_{3, 116}$=13.95; P<0.001) followed by Duncan homogeneity test. The values with same alphabet in superscript are not significantly different at P=0.05

due to waste disposal and vehicle movement. The *Parthenium* cover and maximum height also differed significantly (P<0.001) with land use (Figs. 5 and 6). The lowest density, cover as well as maximum height of *Parthenium* in abandoned agriculture land could be due to a short history of invasion as compared to other land-use types.

Species richness

All together 47 plant species were recorded in the sampling plot (Table 1). Plant species richness declined with increasing density of *Parthenium* in wasteland (Fig. 7A). Gebeyehu, (2008) also found that *Parthenium* reduced the abundance of plants in the waste lands. The density of associated plant species also declined with increasing density of *Parthenium* (Karki, 2009, Timsina, *et al.,* 2011). Reduction in species richness and abundance of other species in *Parthenium* invaded sites could be due to its high reproductive capacity and allelopathic effect (Mekonnen, 2017). The relation between species richness and *Parthenium* density in remaining three land-use types was not significant (Fig. 7B-D). It might be due to the initial phase of invasion of *Parthenium*.

Table 1: List of the plant species recorded in the sampling plots

Serial Number	Name of the species	Serial Number	Name of the species
1	*Ageratina adenophora L.* (Sprengel) R. M. King and H. Robinson (*Eupatorium adenophorum* Sprengel)	24	*Hydrocotyl* sp.
2	*Achyranthes bidentata* Blume	25	*Ipomoea muricata* L.
3	*Ageratum conyzoides* L.	26	*Ixeris gracilis* (DC) Stebb.
4	*Alternanthera sessilis* L.	27	*Justicia* sp.
5	*Artemisia indica* Willd.	28	*Lantana camara* L.
6	*Bidens pilosa* L.	29	*Mimulus nepalensis* Benth.
7	*Carex lenta* D.Don	30	*Oenothera rosea* (L.) Herit & Aiton
8	*Centella asiatica* (L.) Urb.	31	*Oxalis corniculata* L.
9	*Cestrum nocturnum* L.	32	*Persicaria barbata* (L.) Hara
10	*Chloris* sp.	33	*Plantago erosa* Wall.
11	*Cirsium verutum* (D.Don) Spreng.	34	*Polygonum* sp.
12	*Coriandrum sativum* L.	35	*Ranunculus* sp.
13	*Cynodon dactylon* (L.) Pers.	36	*Sacciolepsis indica* L.
14	*Cynoglossum zeylanicum* (Vahl) Thunb. ex Lehm.	37	*Setaria virdis* L.
15	*Dichrocephela integrifolia* (L.f.) O. Kuntze	38	*Sida acuta* Burm. f.
16	*Digiteria violascens* L.	39	*Solanum aculeatissimum* Jacq.
17	*Drymaria diandra* Blume	40	*Solidago* sp.
18	*Duchesnea indica* (Andr.) Focke	41	*Sporobolus fertilis* (Steudel) W.D. Clayton
19	*Equisetum* sp.	42	*Stellaria media* L.
20	*Flemangia* sp.	43	*Trifolium repens* L.
21	*Galinsoga parviflora* Cav.	44	*Trumfetta pilosa* Roth
22	*Geranium ocellatum* Cambess.	45	*Verbena officinalis* L.
23	*Grevillea robusta* A.Cunn. ex R.Br.	46	*Vernonia cinerea* (L.) Less.
24	*Hydrocotyl* sp.	47	*Xanthium strumarium* L.

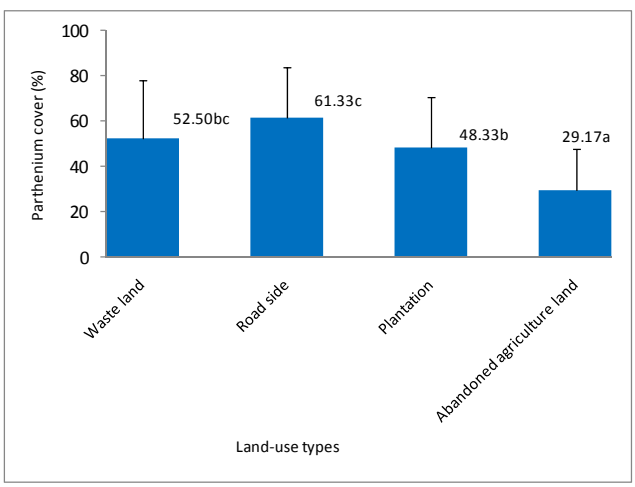

Fig. 5: *Parthenium* cover in different land-use types. The mean values were compared by ANOVA ($F_{3, 116}$=11.11; P<0.001) followed by Duncan homogeneity test. The values with same alphabet in superscript are not significantly different at P=0.05

During the initial phase of invasion *Parthenium* may allow other species to grow in its vicinity. *Parthenium* invasion at early stage might have also increase habitat heterogeneity in road side, plantation and abandoned agriculture land as reported by Timsina, *et al.,* (2011) in grasslands. Over the time, as *Parthenium* density increases, richness of other species may decline due to competition as well as allelopathic interferences.

Peoples' perception

Among the total respondents, 83% noticed *Parthenium* weed in their surrounding though

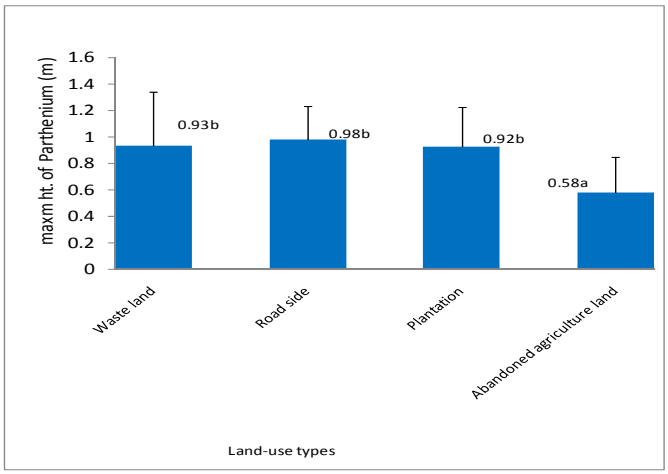

Fig. 6: Maximum height of *Parthenium* in different land-use types. The mean values were compared by ANOVA ($F_{3, 116}$=10.15; P<0.001) followed by Duncan homogeneity test. The values with same alphabet in superscript are not significantly different at P=0.05

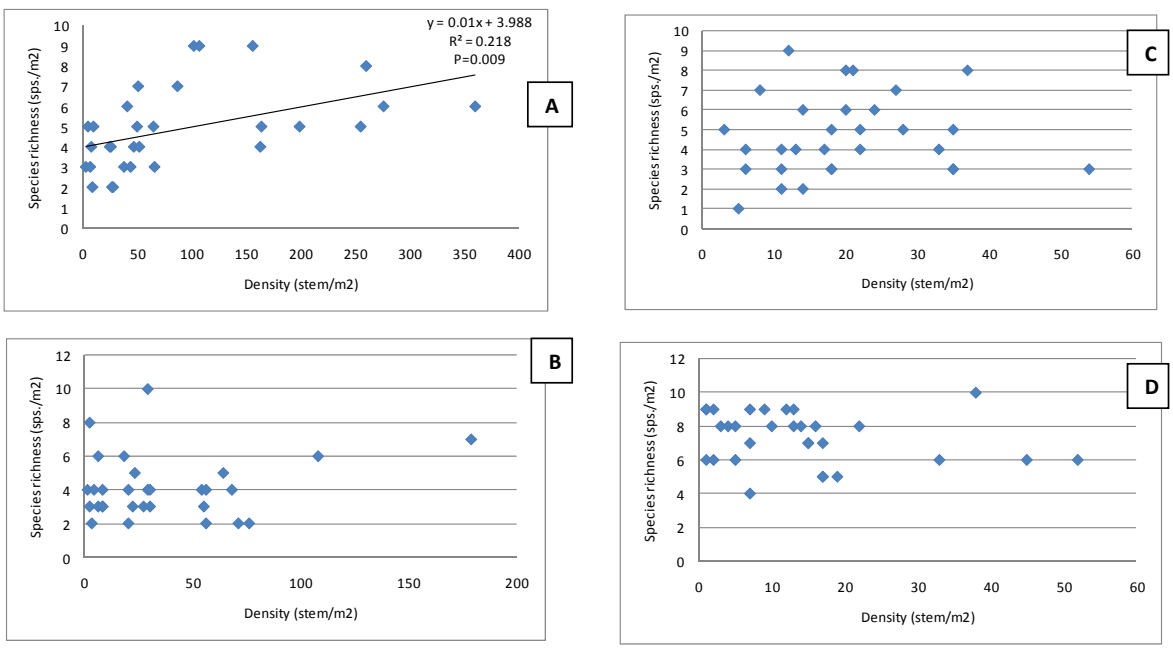

Fig. 7: Variation of flowering plant species richness with the density of *Parthenium* weed in different lands-use types: A) waste land, B) road side, C) tree plantation and D) abandoned agriculture land. Regression line was fitted when the relation was significant

most of them (75%) didn't know the name and its negative impacts to environment and health. Similar situation has been also reported from Uttar Pradesh India (Kapoor, 2012). This is primarily due to lack of community education related to invasive weed in developing countries (Strathie, *et al.*, 2011). About 8% of the respondents incorrectly called it Titepati (*Artemisia indica*) because it looks similar to *Parthenium* in vegetative stage. About 63% of the respondents noticed the presence of *Parthenium* for 8-9 years in their area, but 20% respondent said that they observed this weed for 4-5 years. Most of the respondents (65%) noticed that *Parthenium* first appeared in road side. About 83% did not notice any

loss in agriculture yield due to *Parthenium* weed because it is at the early stage of invasion in agro-ecosystem (Shrestha, 2011). About 13% respondents noticed that the weed was consumed by goat. (Javaid and Anjum, 2005) also reported that *Parthenium* was consumed by goats but not by buffalos, cows and sheep in Pakistan. About 38% of the respondents noticed that the *Parthenium* weed has spread so rapidly that they would face serious problem in managing this weed in near future. About 83% did not notice any health problems for cattle. (Kapoor, 2012) also reported that majority of the rural people in Uttarpradesh, India had no idea about the negative impact of *Parthenium* on domestic animals. About 8% of the respondents noticed the skin allergies and dermatitis for human due to regular contact with *Parthenium* weed but they didn't take any medical treatment for this problem. Karki (2009) also reported health problem such as skin allergies, wounds, boils, eye redness, cough and throat problems, fever and asthma for human on regular contact with *Parthenium* in Bharatpur and Hetauda. Health related problems of this weed have been also reported from other parts of Nepal (Shrestha, *et al.,* 2015) as well as other counties in its introduced range (Adkins and Shabbir, 2014).

CONCLUSION

Parthenium was at the early stage of invasion in Kirtipur Municipality as only 15% of the survey plots had *Parthenium* weed and 2.3% plots had >50% cover of this weed. The frequency (%) of plots with *Parthenium* varied with land-use types; it increased in the following order: grass land (0.49%), abandoned agriculture land (0.68%), shrub land (0.98%), plantation (1.08%), road side (3.2%) and waste land (8.46%). The weed was the most frequent in wasteland and had low frequency in active agriculture lands. In wasteland plant species richness decline with increase the density of *Parthenium*. The significant difference ($P<0.001$) was observed in *Parthenium* density across land use types with the highest density in the waste land. It was more common in urbanized north-east part of Kirtipur Municipality than in peri-urban south-west part. The urbanized north-east part is dominated by road network and residential area while the peri-urban south-west part is dominated by forest and agriculture land. In Kirtipur municipality hundreds of vehicles move along Hetauda-Kathmandu highway which might be the main source of introduction of *Parthenium* in municipality. Local people were not adequately aware of the identity of *Parthenium.* Regarding its health impacts few local people noticed the impact such as skin allergies and dermatitis due to regular contact with *Parthenium.* Management of this weed through community education and participation can help to prevent further spread of this weed into agriculture lands and other natural ecosystems.

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CONFLICT OF INTEREST

The author declares that there is no 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

%	Percentage
()	Bracket
°	Degree
′	Minute
″	Second
<	Greater than
>	Less than
ANOVA	Analysis of Variance
eq.	Equation
etc.	et cetera
Fam	Family
GIS	Geographic Information System
GoN	Government of Nepal

ht	Height
i.e.	that is
ICIMOD	International Centre for Integrated Mountain Development
m	meter
m^2	Square meter
MENRIS	Mountain Environment and Natural Resource Information System
NTNC	National Trust for Nature Conservation
P	Probability
R^2	Coefficient of determinant
sp.	Species
sps./m^2	Species per meter square
SPSS	Statistical Package for Social Sciences
sq km	Square Kilometer
stem/sq.m	Stem per square meter
TUCH	Tribhuvan University Central Herbarium
via	Through
X	Multiply

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