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Effect of Hill-cutting on plant community: A case study in the subtropical forest of Raid-Marwet region, Ri-Bhoi district of Meghalaya, India

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Abstract

Degradation of forestlands into small patches dramatically changes the quality of the forest and wildlife habitats. An attempt was made to assess the impact of forest degradation on two sites and to compare it with relatively undisturbed site (control) in Raid-Marwet region of Ri-Bhoi district, Meghalaya, India. A variety of methods have been used for estimation of richness or biodiversity, which includes diversity indices such as Simpson's index, Berger-Parker index, and Shannon index to assess the various vegetation parameters. Apart from species diversity, life-forms of plants are described by Importance value Index (IVI), and further extrapolation of the species densities. List-Court Quadrat method has been used to record the individuals of each plant species represented in the quadrat. Species represented by very low IVI were *Ficus racemosa* (1.09), *Ficus benghalensis* (1.09), *Ficus religiosa* (1.51), *Ficus elastica* (1.80), *Desmodium caudatum* (1.71), *Datura metel* (2.51), *Coix lacrima-jobi* (4.77), and *Bambusa tulda* (4.92). Site 1 and site 2 showed high diversity index (with dominating invasive species like, *Chromolaena adorata*, *Mikania micrantha*, *Mimosa pudica*, and *Lantana camara*), whereas frequency, density and dominance were comparatively high in the control site. Based on the study, it may be concluded that the forest areas which are unprotected and are close to human habitation have experienced the damaging effects of forest degradation.

Keywords: Diversity Index, IVI, Quadrat method, Hill-cutting

Introduction

The north eastern region has been in focus for its high biodiversity and the region has gained priority by the leading conservation agencies of the world. WWF has identified the entire Eastern Himalayas as a priority Global 200 Ecoregion, while Conservation International has upscaled the Eastern Himalaya Hotspot which initially covered the states of Arunachal Pradesh, Sikkim, Darjeeling Hills, Bhutan, and Southern China to the Indo Burma Hotspot (Myers 2000). This includes all the eight states of North-East India, along with the neighboring countries. A variety of methods have been proposed for managing richness or biodiversity on earth, including increased attention to the mega-diverse countries having high species richness and to 'hot-spots' with high numbers of endemic species (Rohde 1992). Habitat destruction is among the major causes of loss of plant diversity worldwide, although restoration efforts are being made to ameliorate the disturbed ecosystems and their valuable biodiversity. An essential prerequisite of any vegetation measurement for inventory purpose is to have an extensive survey of the area. There is a great need for having both qualitative and quantitative idea of biota present in order to have an idea about the level interference in any area.

The topography and climate of Raid-Marwet region favors growth of rich biota, but degradation of hills in some regions of Ri-Bhoi district, Meghalaya have become a major challenge. The highly effected sectors of region are its weather and climate, geomorphology and hydrology, and the indigenous flora and fauna (Biodiversity). Deforestation and resulting increased soil erosion, decreased ground water recharge and deteriorated water quality might also be as consequences of hill cutting. This, coupled with shifting cultivation, stone quarrying, etc. are the major causes of forest degradation and biodiversity loss. All these anthropogenic activities play an important role in environmental changes and loss of plant diversity of the region. In view of the above, the present study will emphasize on the assessment of the vegetation of the region, with floral diversity status of the existing forest, and the impact of hill cutting in the region.

Materials and Methods

Study area

Ri-Bhoi District is one of the seven Districts of Meghalaya, carved out from the erstwhile East Khasi Hills District on 4th June 1992. It is bounded in the North by the Kamrup District of Assam, East by the KarbiAnglong District of Assam, South by the East Khasi Hills and West by the West Khasi Hills District. Ri-Bhoi District covers an area of 2448 km2 with a population of 258,380 (India census 2011). It lies between 90°55' to 92°05' E Latitude and 25°40' to 26°20'N Longitude. Raid-Marwet with total area of 155 km2 is located between 91°43' to 91°53' E Latitude and 25°57' to 26°07' N Longitude (Figure 1). This region is characterized by rugged and irregular land surface. It includes a series of hill ranges which gradually sloped towards the North and finally joins the Brahmaputra Valley.

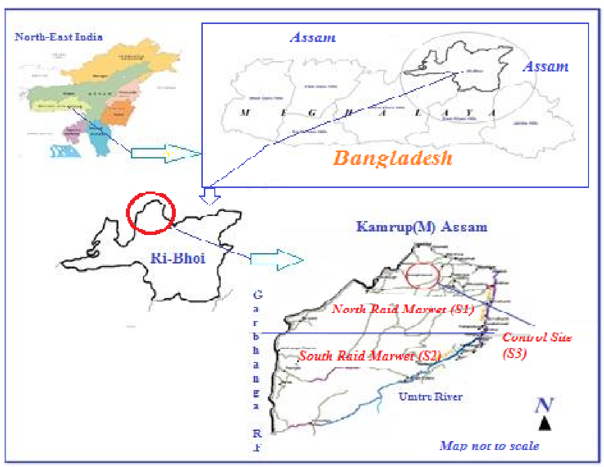

Figure 1: Study area

Methodology

An intensive field survey was conducted in the hills of Raid-Marwet region, Ri-Bhoi District of Meghalaya. Vegetation analysis was done by random-systematic design and quadrat methods (Barbour et al. 1999; Singh & Singh 1992). The study area was divided into three parts (Site 1: North Raid-Marwet (S1), Site 2: South Raid-Marwet (S2), and Site 3 control) (S3)): Nongthemai Garo community forest). In the whole area 20 nested quadrats of the dimensions 1m x 1m (grasses), 5m x 5m (herbs/shrubs etc.) and 10m x 10m (trees) were laid, List- Court quadrat boundaries of 1, 5, and 10 meter on a side form $1m^2$, $25m^2$, and $100\ m^2$, respectively, and were used extensively for counts of individual's grasses, herbs, shrubs, and tress. A parallel control (least disturbed) was also selected to compare the species richness, diversity and composition of vegetation in the study areas. All the plant species appeared in both the sites (S1 & S2) and control site (S3) quadrat were sampled, the sample were hence identified with the help of available literature (Kanjilal et al. 1934-40; Hooker 1872-97). The following vegetation attributes were calculated:

$$\text{IVI of a species} = \text{Relative Density} + \text{Relative Frequency} + \text{Relative Dominance or Relative Cover}$$

Relative Density + Relative Frequency + Relative Cover has been used for calculating IVI of herbaceous vegetation (Rastogi 1999; Sharma 2003) whereas Relative Density + Relative Frequency + Relative dominance is used for calculating IVI of woody vegetation (Mishra 1968).

$$\text{Density} = \frac{\text{Total number of individuals of the species}}{\text{Total number of Quadrats studied}}$$

$$\text{Relative Density} = \frac{\text{Density of individual species}}{\text{Total density for all species}} \text{ x } 100$$

$$\text{Frequency (F)} = \frac{\text{Number of Quadat occupied}}{\text{Total number of Quadrat examined}}$$

$$\text{Relative Frequency (RF)} = \frac{\text{Frequency of individual species}}{\text{Total Frequency of all species}} \text{x100}$$

Dominance = Basal Area x Density, where Basal area (B) = πr^2 Where: π = 3.1 4, r = Radius.

$$\text{Relative Dominance} = \frac{\text{Doninance of individual species}}{\text{Total Dominance for all species}} \text{ x } 100$$

$$\text{Relative Cover} = \frac{\text{Species occurance in the sampling unit}}{\text{Total occurance}} \text{ x100}$$

$$\text{Extrapolation}\left(\frac{\text{Avg. Density}}{\text{ha}}\right) = 10{,}000 \frac{\text{m}^2}{\text{ha}} \text{ x Density of the individual species.}$$

PAST Version 2.15 was used to calculate the various diversity indices based on (Berger & Parker 1970; Simpson 1964; Shannon & Wiener 1963). ArcGIS 9.3 was used to digitize the Survey of India (SoI) Topographic Sheet ($78\frac{O}{9}, 78\frac{O}{13}, 78\frac{N}{12}$, and $78\frac{N}{16}$) and the Satellite imagery (LISS-III sensor IRS-P6 (Resourcesat-1) with 24 meter spatial resolution (13G46H16_09NOV09_ b234, 13G46N09_09NOV09_b234, 13G46N13_09NOV09_b234 and 13G46H12_09NOV09_b234 for the year 2009) to extract the hill cutting scenario between the year 1997 (SoI) and 2009 (satellite imagery).

Results and discussion

From the quantitative ecological analysis using various parameters to calculate the IVI and Extrapolation (i.e. the average density per hectare), the highest value among grass species (Table 1) were, *Cenchrus ciliaris*, *Cyperus rotundus*, *Cymbopogon citratus*, and *Paspalum notatum* in the control site. But in site 1, having the highest value was observed in case of *Dendrocalamus hamiltonii*, *Bambusa tulda*, and *Cyperus brevifolius*. In site 2, *Cenchrus ciliaris*, *Echinochloa colonum*, and *Heteropogon contortus* showed the highest value. Majority of the grass species falls under the family Poaceae.

Table 1: Important Value Index (IVI) and Extrapolation of Grass Species in the study area

Grass species	IVI (S1)	E (m^2/ha)	IVI (S2)	E (m^2/ha)	IVI (S3)	E (m^2/ha)
*Arundo donax*L.	21.39	129000	19.86	42500	-	-
Axonopus compressus (Sw.) P. Beauv	-	-	13.01	44000	-	-
Bambusa bambos (L.) Voss	4.92	13000	-	-	17.77	23000
Bambusa tulda Roxb.	29.58	192000	8.71	19000	14.82	25000
Cenchrus ciliaris L.	16.98	89000	40.90	135000	77.13	633000
Chrysopogon aciculatus (Retz.) Trin	-	-	22.46	56000	-	-
Coix lachryma-jobi L.	-	-	4.77	6000	-	-
Cymbopogon citratus (DC) Stapf.	24.78	149000	23.04	58000	55.45	280000
Cymbopogon nardus (L.) Peres.	14.40	56000	-	-	-	-
Cynodon dactylon (L.) Pers.	15.25	95000	19.72	53500	-	-
Cyperus brevifolius (Rottb.) Hassk	24.65	153000	7.71	13500	-	-
Cyperus rotundus L.	-	-	18.87	50000	57.83	463000
Dendrocalamus hamiltonii Nees.	34.25	308000	-	-	21.16	47000
Digitaria milanjiana	14.97	92000	12.75	34000	-	-
Echinochloa colona (L.) Link	20.41	115000	39.34	102000	-	-
Heteropogon contortus P.Beauv.	20.07	133000	23.66	74000	27.27	138000
Imperata cylindrica (L.) P. Beauv.	18.36	112000	8.88	18000	-	-
Panicum repens L.	23.07	125000	16.78	46000	-	-
Paspalum conjugatum Berg.	-	-	13.49	37000	-	-
Paspalum notatum Fiugge.	-	-	-	-	42.01	280000
Saccharum spontaneum L.	16.85	141000	6.62	18000	-	-

IVI=Important Value Index, E= Extrapolation, S1= Site 1, S2=Site 2 S3= control

Observation on herbs/shrubs/climbers in the study area (Table 2) revealed *Bauhinia acuminata* and *Achyranthes aspera* having highest values, in the control site. Comparatively in S1 & S2, highest IVI was found in case of *Mikania micrantha*, *Mimosa pudica*, *Chromolaena adorata*, *Bauhinia acuminata*, and *Lantana camara*. It is also found that majority of the herbs/shrubs/climbers falls under family Asteraceae, followed by Araceae, Verbenaceae, Fabaceae, and Papilionaceae. Since control site is the least disturbed site in the study area, so dominance of invasive species is not that well marked but on the contrary, it has been observed that in both S1 and S2 which are under anthropogenic threats harbor a wide range of invasive species, many of which are herbs/shrubs including *M. micrantha, M. pudica, L. camara*, and *C. adorata*. From the finding of Okereke & Mbaekwe (2011) it is well quoted that Mimosa sp. has the ability to dominate and suppress all other species around it due to its high competitive ability in any environment. Even though invasion persists in S1 and S2, diversity of vegetation composition is not that affected till now, but scenario may worsen in near future. Kercher & Zedler (2004) reported that - an increase in abundance of the invaders can decrease the diversity of species.

Table 2: IVI and Extrapolation of Herbs/shrubs/climber species in the study area

Herbs/shrubs/climber species	IVI (S1)	E (m^2/ha)	IVI (S2)	E (m^2/ha)	IVI (S3)	E (m^2/ha)
Achyranthes aspera L.	17.63	61000	12.00	17000	84.79	339000
Ageratum conyzoides L.	13.56	43000	18.68	27500	-	-
Alocasia indica (Lou.) Koch	2.3	6500	6.92	5500	-	-
Alocasia odora (Roxb.) Koch	16.46	55000	8.86	9500	-	-
Barleria prionitis L.	10.5	275000	6.60	7000	-	-
Bauhinia acuminate L.	19.82	69500	22.90	34000	86.04	357000
Callicarpa arborea Roxb.	7.3	13000	8.86	9500	-	-
Cardamine hirsute L.	-	-	17.12	26500	-	-
Centella asiatica (L.) Urban	17.47	52500	21.34	33000	-	-
Chromolaena adorata (L.) Voigt.	21.4	77500	29.21	47000	15.05	29000
Curcuma aromatic Salisb.	-	-	-	-	11.93	26000
Datura metel L.	2.51	5000	6.20	4000	-	-
Desmodium caudatum (Thunb.) DC.	10.4	27000	2.28	2500	-	-
Diascorea alata L.	-	-	-	-	15.35	24000
Euphorbia hirta L.	11.45	32500	15.35	40000	-	-
Flemingia strobilifera (L.) Br.	13.28	36500	24.42	12000	-	-
Ipomoea batatas(L.) Lamk.	18.33	64500	5.53	7000	-	-
*Lantana camara*L.	18.51	68000	23.62	35500	15.09	24000
Leucas aspera Spreng.	7.09	20500	26.78	42000	23.21	61000
Luffa acutangula(L.) Roxb.	17.43	57500	-	-	-	-
Mikania micrantha Kunth. ex H.B.K.	34.3	135000	23.08	30000	14.57	32000

Mimosa pudica L.	34.09	139000	20.47	29000	10.11	11000
Parthanium hysterophorus L.	-	-	-	-	11.31	11000
Phyllanthus reticulatus Poir.	-	-	-	-	8.61	9000
Rauvolfia serpentine Benth.	6.2	13500	4.10	3500	10.94	15000
Senna sophera(L.) Roxb.	-	-	7.66	7000	-	-

IVI=Important Value Index, E= Extrapolation, S1= Site 1, S2=Site 2, S3 = Control

In the study area the trees like, *Acacia auriculiformis,* and *Artocarpus chama* showed highest value in control site. In S1 and S2, *Tectona grandis*, *Dalbergia sissoo,* and *Delonix regia* showed the highest value (Table 3). The dominating families among the recorded tree species are Combretaceae, Moraceae, Caesalpinaceae, Fabaceae, Anacardiaceae, and Rutaceae.

Table 3: Important Value Index (IVI) and Extrapolation of tree species in the study area

Trees species	IVI (S1)	E (m²/ha)	IVI (S2)	E (m²/ha)	IVI (S3)	E (m²/ha)
Acacia auriculiformis A. Cunn. exBenth.	20.37	42500	9.51	7000	38.59	77500
Aegle marmelos Correa	5.13	5000	4.62	3000	-	-
Albizia lebbeck (L.) Benth.	-	-	-	-	16.59	25700
Alstonia scholaris (L.) R. Br.	6.95	12500	9.98	8000	-	-
Annona reticulata L.	7.95	12000	10.88	7000	-	-
Anthocephalus cadamba Miq.	6.47	9500	10.88	8500	9.06	14000
Artocarpus heterophyllus Lamk.	6.29	9000	6.62	4500	15.96	24200
Artocarpus chama Buch.-Ham.	-	-	-	-	36.48	65000
Averrhoa carambola L.	7.31	14500	4.62	3000	-	-
Azadirachta indica A. Juss	4.96	2500	3.26	1500	-	-
Bauhinia variegata L.	11.75	19000	6.34	3500	-	-
Cassia fistula L.	13.04	28500	5.98	4500	12.27	15700
Cinnamomum tamala (Buch.–Ham) Nees ex Ebem	7.28	8500	10.69	9000	-	-
Citrus grandis (L.) Osbeck	6.44	7200	4.61	3000	-	-
Citrus maxima Merr.	9.79	17000	5.95	4000	-	-
Corymbiama culata (Hook.) K. D. H	12.26	27500	11.15	9500	-	-
Croton joufra Roxb.	11.52	21500	10.89	8500	-	-
Dalbergia sissoo Roxb.	17.56	36000	12.87	10000	10.69	15000
Delonix regia (Boj. Ex Hook.) Raf.	-	-	14.04	12000	-	-
Duabanga grandiflora (Roxb.ex DC) Walp.	-	-	-	-	6.47	10000
Dillenia indica L.	6.48	9500	5.29	3000	14.03	23300
Erythrina stricta Roxb.	10.17	18000	12.42	9500	12.02	18300
Ficus benghalensis L.	-	-	1.09	500	-	-
Ficus benjamina L.	-	-	2.16	1000	-	-
Ficus elastica Roxb.	2.35	3000	4.16	2500	-	-
Ficus hispida Vahl.	4.51	14600	4.66	3000	-	-
Ficus racemosa L.	-	-	1.09	500	-	-
Ficus religiosa L.	1.78	2900	2.17	1000	-	-
Jatropha curcas L.	12.9	44600	7.47	5500	-	-
Lagerstroemia parviflora Roxb.	-	-	-	-	12.37	20000
Lagerstroemia speciosa (L.) Pers.	-	-	-	-	13.78	18300
Lannea grandis (A. Rish.)	9.20	15500	7.97	6000	-	-
Lawsonia inermis L.	-	-	8.25	6500	-	-
Litchi chinensis Sonn.	-	-	-	-	11.46	25700
Mangifera indica L.	7.28	8500	6.20	4000	8.34	15000
Magnolia champaca L.	-	-	-	-	15.37	22900
Moringa oleifera Lamk.	8.43	13500	10.62	7000	-	-
Psidium guajava L.	5.31	14600	4.661	3000	-	-
Schima wallichii (DC) Kuntz.	-	-	-	-	9.17	17500
Senna siamea Lamk.	-	-	3.72	2000	-	-
Sterculia villosa Roxb.	10.17	18000	7.65	5500	-	-
Tamarindus indica L.	8.81	14500	4.16	2500	10.02	13300
Tectona grandis L. f.	21.67	42500	27.64	27000	9.06	14000
Terminalia bellerica (Gaertn.) Roxb.	8.01	14500	3.73	2000	13.51	18600
Terminalia chebula Retz.	5.10	12800	3.73	2000	11.02	12800
Terminalia myriocarpa Heurck et Muell.	-	-	-	-	14.13	20000
Thevetia peruviana (Pers.) K.Schum.	-	-	6.16	4000	-	-
Vachellia farnesiana (L.) Wright et Arn.	16.41	30000	12.88	10000	-	-
Ziziphus mauritiana Lamk.	5.29	8500	9.075	6500	-	-

IVI=Important Value Index, E= Extrapolation, S1= Site 1, S2=Site 2 S3=Control

Observation on diversity of species in the study area (Table 4) base on Berger-Parker, Simpson's and Shannon diversity index, showed that trees are highly diverse in all the three sites followed by herbs/shrubs. High diversity of herbs/shrubs/climbers in S1 and S2 in comparison to the Control site is mainly due to presence of many invasive and weeds species. Present study in different sites of the forest reveals damaging effect of the anthropogenic interference, which may decrease the species diversity and species dominance. Similar observations were made by (Sher et al. 2005; Skornik et al. 2010; Mushtaq & Pandit 2010) which showed that frequency, density and dominance have a serious impact due to anthropogenic activities, ultimately affecting the importance value of the species. During the study, it was observed that the control site has few species with greater individual numbers, in comparison to other two sites (S1 and S2), which are under serious threats. Similar observations were also made by (Lone & Pandit 2005; Kumar et al. 2004; Rajwar & Gupta 1992; Mishra et al. 2002).

Table 4: Ecological Diversity Indices and their comparison

Ecological Diversity Indices By/At	Berger-Parker index (D_{BP})	Simpson's index 1-D	Shannon Index H
Control Site			
Grasses	0.3347	0.7774	1.671
Herbs/shrubs	0.379	0.7178	1.649
Trees	0.1721	0.9159	2.773
Site 1			
Grasses	0.1084	0.0754	2.629
Herbs/shrubs	0.1384	0.07585	2.746
Trees	0.08244	0.4415	3.281
Site 2			
Grasses	0.1675	0.08541	2.622
Herbs/shrubs	0.09802	0.06262	2.912
Trees	0.1239	0.04286	3.403

Besides various levels of damaging effects on the vegetation, the study area reveals some other forms of environmental degradation, among them hill cutting being the most serious one, followed by shifting cultivation, illegal timber harvesting, etc. Figure 2 clearly quantifies the scenario of hill cutting in the study area. In the year 1997 approximately 8.09 km^2 of hill was completely lost, north Raid-Marwet (S1) with 6.06 km^2 and South Raid-Marwet (S2) with 2.02 km^2. After more than a decade i.e. in 2009, this figure climbed to approximately 15.36 km^2 with high increase in S1 (10.75 km^2) and S2 (4.61). This is increasing at an average rate of 0.390 km^2/year in S1 and 0.214 km^2/year in S2.This aspect deserves immediate attention in the interest of restoration and reclamation of the ecosystem of the area.

The forests provide various products such as fuel-wood, construction material, timber, medicinal plants, animal fodder, and edible plants etc. Despite their socio-economic and ecological importance, at present, the forests are under immense human pressure. Extrapolation of the species density (m^2/ha) in the study area are shown in Table 1-4 respectively, and it is also seen that hill cutting is accelerating at an average rate of 0.604 km^2/ year, it becomes imperative to protect the species with low IVI and density values from local extinction. IVI value is an important parameter that reveals the ecological significance of species in a given ecosystem (Lamprecht 1989). Species with high IVI values are considered more important than those with low IVI value. The IVI values can also be used to prioritize species for conservation, and species with high IVI value need less conservation efforts, whereas, those having low IVI value needs high conservation effort (Shibru 2002).

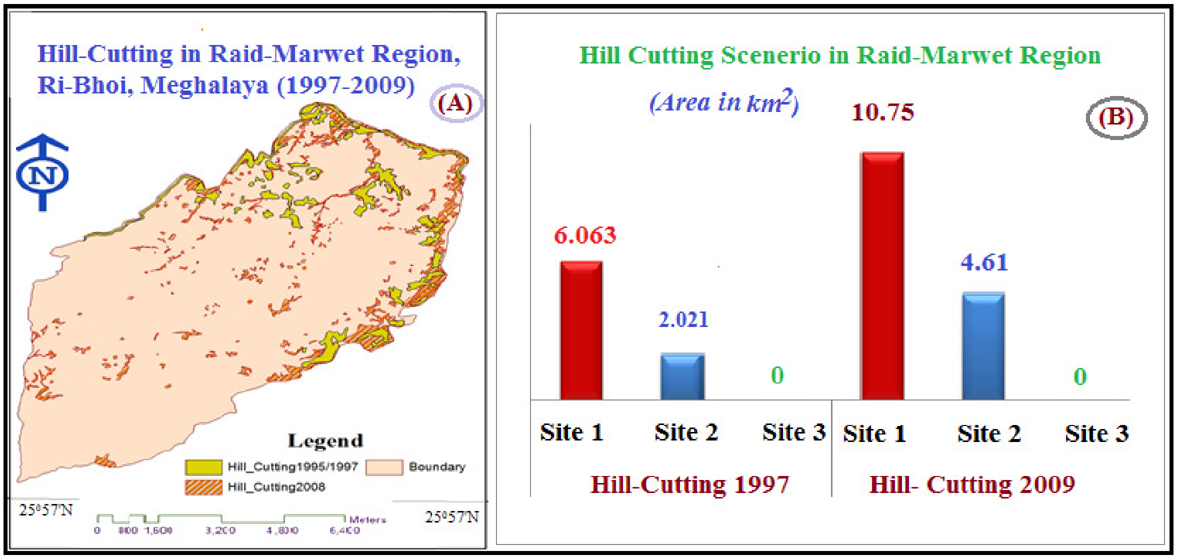

Figure 2: Hill Cutting scenario in the study area. (A) Mapping hill cutting scenario in the study area in two time scale (B) Graphical representation of hill cutting in three sites

In the present study species with low IVI values, which needs much attention are, *Ficus racemosa, Ficus benghalensis, Ficus religiosa, Ficus elastica, Anthocephalus cadamba, Duabanga grandiflora, Mangifera indica, Aegle marmelos, Azadirachta indica, Citrus grandis, Terminalia chebula,Terminalia bellirica, Desmodium caudatum, Datura metel, Coix lachryma-jobi, Saccharum spontaneum, Cyperus rotundus, Imperata cylindrica, Parthenium hysterophorus, Alocasia indica, Callicarpa arborea, Ipomoea batatas,* and *Rauvolfia serpentina*.

Conclusion

The results suggest that the species having low IVI value should be given priority if conservation measures are to be implemented. Therefore, it is recommended for conservation, management and sustainable utilization of the existing forest resources that are under serious anthropogenic influence. It has been observed that the loss of forest in central Himalayan region results in severe, ecological and economic cost, lost watershed protection, regional climate change, reduced supply of timber, fuel wood, fruits etc, and also affects people's lives (Jagdish et al. 1997). In the same way, it can be said that if this act of hill cutting in Raid-Marwet Region is left unchecked, the consequences will be directly on human well-being affecting the socio-economic condition of the indigenous community.

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Water Faecal Contamination and Household Morbidity in Slums of M-Ward, Mumbai, India

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Abstract

This study was conducted in slums of Shivaji Nagar, an urban slum in the western M-Ward of Mumbai, India. Two slums within the area were selected, the water samples were collected from the point of use and H_2S water testing was done in resettled (Natwar Parekh Compound, 80 samples) and non-resettled (Raffiq Nagar, 72 samples) slums. Study showed that the households where the quality of water was better the morbidity conditions in those households were low as compared to the other households. Households taking water from tanker trucks were more affected by the faecal contamination of the water and more prone to water borne diseases. Source of water and access to water source (public or community water sources) was associated with diseases like fever and cough. Thus, a strong association of poor water quality with the incidence of diseases was found whether it was a resettled slum or non- resettled slum. Thus, attention must be given towards developing practical strategies to ensure safe drinking water, provided at the point of supply and consumption, also practices towards water storage handling and consumption needs to be improved no matter it is a resettled or a non-resettled slum or any other place of human habitation which will lead to reduction in water borne diseases and improved overall health.

Keywords: Faecal contamination, Drinking Water, Slum, H_2S test, morbidity, Mumbai

Introduction

The importance of water to human health and wellbeing is well mentioned in the Human Right to Water and Sanitation, which entitles everyone to ''sufficient, safe, acceptable physically accessible and affordable water for personal and domestic uses'' (Committee on Economic Social and Community Rights 2002) Water is essential to sustain life, and a satisfactory (adequate, safe and accessible) supply must be available to all. Improving access to safe drinking water can result in tangible benefits to health. Every effort should be made to achieve drinking-water that is as safe as practicable. Securing the microbial safety of drinking water supplies is based on the use of multiple barriers, from catchment to consumer, to prevent the contamination of drinking-water or to reduce contamination to levels not injurious to health. Safety of water is increased if multiple barriers are in place, including protection of water resources, proper selection and operation of a series of treatment steps and management of distribution systems along with the storage and handling at the household level (WHO 2011).

The quality of drinking-water thus may be controlled through a combination of protection of water sources, control of treatment processes and management of the distribution and handling of the water. Health-based targets should be based on an evaluation of health concerns system assessment to determine whether the drinking-water supply (from source to the point of consumption) as a whole can deliver water that meets the good health targets (WHO 2006).

Contaminated drinking water, along with inadequate supplies of water for personal hygiene and poor sanitation, are the main contributors to an estimated 4 billion cases of diarrhoea each year causing 2.2 million deaths, mostly among children under the age of five and affects millions of people worldwide with waterborne diseases like typhoid, cholera and so on (Clasen 2003). Under guidelines established by the World Health Organization (WHO), water intended for human consumption should contain no microbiological agents that are pathogenic to humans (WHO 2009).The quality of drinking water is a significant environmental determinant of health. Management of drinking water quality is the basis for the prevention and control of water borne diseases. Although water is an essential component of life, it is responsible for transmitting a number of diseases in all the countries and continents from poorest to wealthiest. Unsafe drinking water can cause several communicable diseases such as diarrhea, cholera, typhoid, dysentery and so on (Quick et al. 1999).

There are several ways in which faecal contamination of water can happen. These include contamination of drinking-water catchments (e.g. by human or animal faeces), water within the distribution system (e.g. through leaky pipes or obsolete infrastructure) or of stored household water as a result of unhygienic storage and handling (Mehta 2012). Faecal coliform bacteria or E Coli is the main indicator of the presence of faecal waste in water. It may also contain viruses, parasites and other bacterias. Contamination of drinking water with such organisms can cause major water borne diseases which can even lead to death. These effects are most dangerous in case of infants, children, elderly persons and people with immune deficiencies (Ashbolt 2004).

Testing the microbial presence in drinking water continues to be widely practiced worldwide in order to understand the water quality and efficiency of distribution system, setting standards and guidelines for good water quality, to prepare water safety plans, assessment of risk levels and management (Schwarzenbach 2010). Other important cause of testing faecal water contamination is to teach people about the microbial water quality and making them aware about the importance of better water sanitation and hygiene conditions and practices. This leads to increased community involvement in the management and monitoring of drinking water, including its sources and treatment (Medema et al. 2003)

Contaminated water, poor sanitation and water conditions represent not only a lack of basic amenities, but also the daily sufferings and susceptibility to various infectious diseases (Jackson 2003). Diseases related to contamination of drinking-water constitute a major burden on public health. The principal risk to health is from ingestion of water contaminated with feces containing pathogens that cause infectious diseases such as cholera and other diarrheal diseases, dysenteries, and enteric fevers (White et al. 1972; WHO 2011). The burden of water-related disease varies according to context and is highest in low-income settings where diarrhea remains a leading cause of deaths (Liu 2012)

Water contamination in urban slums in India is a major challenge. The slum population of India increased from 17.4 per cent of urban population in 2001 to 18.3 percent of total urban population in 2011 (Sivaramakrishnan 2011). Maharashtra had the largest share of urban as well as the slum population of India. More than fifty per cent of Mumbai's population lives in slums. There are many studies indicating poor water and sanitation conditions in these slums. Many slum dwellers do not have access to water taps, and rely on informal water sources with high costs. Water may only be available a few hours a day and is sometimes of bad quality and unfit for drinking Also people do not follow the right storage and water handling practices (Agarwal 2011).

Thus, it is necessary to assess the microbial drinking water presence in order to improve the overall planning, management and handling of the drinking water in the slum community and the households. The aim of the study is to assess the faecal contamination of water in resettled and non resettled slum of Mumbai and analyze the association between faecal contamination and household morbidity. This study will help to understand the role of resettlement of slums in terms of drinking water quality, supervision and administration.

Study area

The area for this study is Shivaji Nagar, an urban slum in the western M-Ward of Mumbai, India. To the northeast of it is a dumping ground, which is surrounded on the eastern and northern side of a branch of the Thane creek. Estimations of the population in the slum vary from 2,00,000 by the government; to at least 6,00,000 by doctors and community health workers of Niramaya Health Foundation, a local NGO. Within the slum area, two specific sites were chosen. First slum was Natwar Parekh Compound (Resettled Slum), the catchment area of 'Doctors For You' (DFY), a local non-profit organization that operates a health facility in a section in the north-west of Shivaji Nagar. This region has been part of a slum rehabilitation project, and people have been moved into permanent housing structures, usually known as vertical slums. The second slum area was Raffiq Nagar (Non- Resettled), located in the north of Shivaji Nagar next to the Deonar dumping ground which 10000 metric tonnes of garbage everyday from different parts of Mumbai (Bhavsar et al. 2012) and a branch of the Thane Creek. This site was not part of the slum rehabilitation program, and people here live in non-permanent or semi permanent structures.

Methodology

Water testing was done in resettled and non-resettled slums of M-ward, Shivajinagar using H_2S water testing kits. The non-resettled area, was not as clearly organized and no register of the households (HH) was available. Systematic approach was adopted in non-resettled area, during initial social mapping it was found out that 18 small street were there in each side of the slum. Hence five streets were selected in each side of the slum. Random street between first and third street were selected and from that starting point next streets were selected with interval of three streets. From each street first 10 households was asked to participate in the survey.In resettled slums, a map of the area was obtained, with 61 numbered apartment buildings. A random selection of 10 buildings was made, and subsequently 10 households were selected for each building. Random starting point between one and ten, and systematically selected the following nine (HH) with a selection interval of ten. The background variables used in the study were Household Size, Education, Religion, Caste, Source of water, Access to water source, Treatment of water, Access to toilet, Cleanliness condition of toilet, Wash hand after toilet, Wash hand before having food, Wash hand before cooking and so on and their correlation with the morbidity conditions in the study slums were seen in the study.

The Hydrogen Sulphide (H_2S) test

The H_2S test is recommended for testing drinking water derived from surface water, boreholes, and rain water sources for faecal contamination (WHO 2006).The reagents used to make the H_2S paper strip test are common laboratory chemicals. By adding a measured amount of "boiled" water and a common liquid detergent to the reagents, a measured amount is impregnated on a piece of absorbent paper and dried in a low-temperature oven. The dried paper strip is placed in a clear small plastic or glass bottle or tube. A water sample is collected in the container containing the reagents and stored in the dark at room temperature for about 3 days. If the sample contains hydrogen sulphide producing organisms, the pad and water turn black. The black colour and the rotten egg smell of hydrogen sulphide clearly indicate that there is a problem. With such an indicator it is not difficult to convince uneducated villagers or slum dwellers that the water may not be safe to drink (Manja et al 1982; Wright 2012).

Figure 1: The H_2S testing kit showing the faecal contamination of water (one with black colour and rotten egg smell)

Household non response, leakage or broken H_2S testing bottles and missing H_2S strips caused the reduction in number of sample to be tested. The total final numbers of water samples tested in the resettled and non resettled slums are given in (fig 2). It shows that 80 samples of water were tested from Natwar Parikh Compund

(Resettled slum) and 72 samples of water were tested from Raffiq Nagar (Non-Resettled Slum).

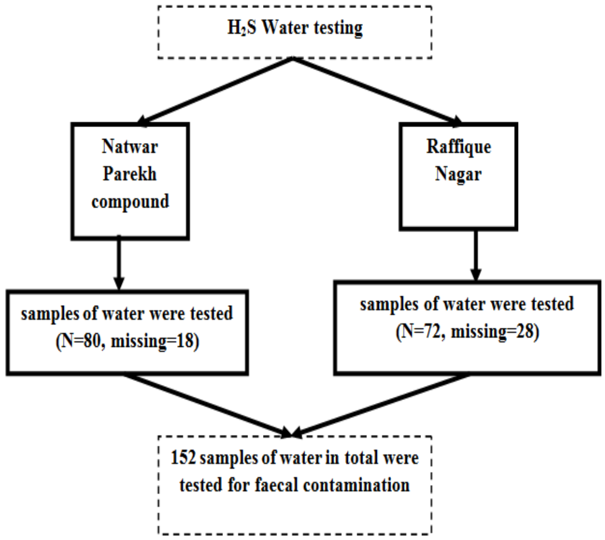

Figure 2: Sample for H_2S water testing

Statistical analysis

Cross tabulation was done to see the faecal contamination and morbidities in the households by type of slums and different socio-economic variables. Spearman's rank correlation was done to see the correlation between these variables. SPSS-version 20 was used to perform this analysis.

Results

In slums of M-Ward, Mumbai, in total 69.7% (106 out of 152) of samples (Fig. 3) were tested positive for faecal contamination. In non-resettled slums, 75% (54 out of 72) of sample were positive for faecal contamination. In resettled slums, 65% (52 out of 80) of sample were found positive for faecal contamination. It was found (Fig.4) that the percentage of households in which the H_2S water test came positive had poorer health conditions. Highest percentage of households was sufferer of cough and fever followed by Diarrhoea. Table 1, shows the correlation between H_2S test results, household morbidities (diarrhoea, fever and cough) with other background variables. It was important to find out that faecal contamination was not significantly related with any of the background variable as well as with household morbidities except for religion and source of water. Household taking water from tanker trunks was positively related with faecal contamination of the water. Belonging to muslim household was also significantly correlated with increased faecal contamination. Increasing household size was positively related with diarrhea. Source of water and access to water source (public or community water sources) was significantly associated with fever and cough. Cleanliness of the toilets were also found significantly negatively correlated with diarrhea and fever. In hygiene practices, habit of washing hands with soap was negatively correlated with diarrhea, fever, cough. All the morbidities were also associated with each other.

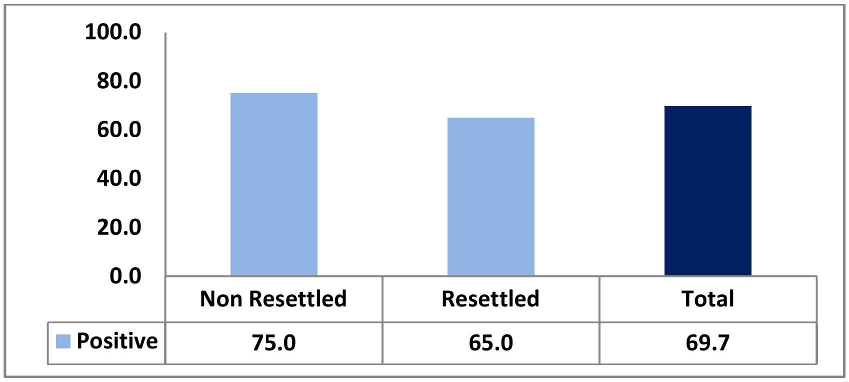

Figure 3: Percentage of water sample resulted into positive for faecal contamination

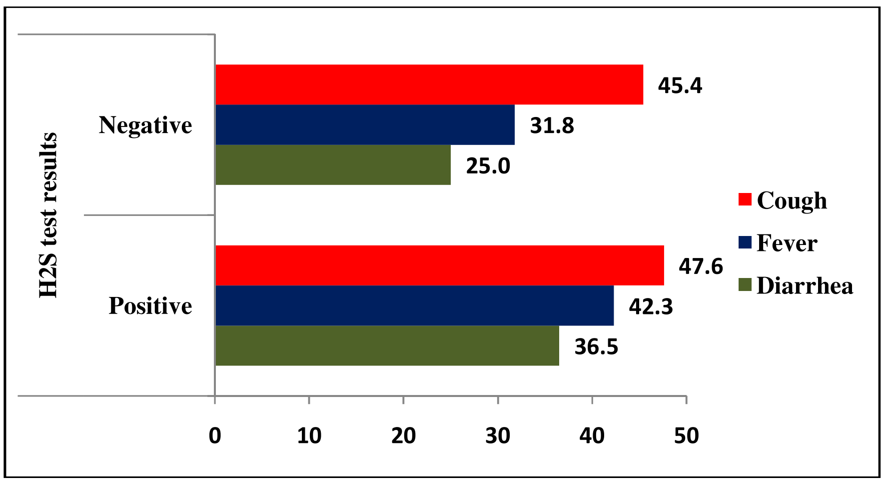

Figure 4: Percentage of households had person with diarrhea, fever and cough by H_2S test result

Table 1: Showing correlation of background variables with H_2S test results and morbidity conditions

Background Variables	H_2S Results	Diarrhea	Fever	Cough
Household Size	-0.108	.211***	0.078	0.078
Education	0.093	-.145**	0.054	0.051
Religion	.219***	-.144**	-.173**	-0.089
Caste	-0.08	-0.039	.240***	0.085
Source of water	0.02	-0.066	-.314***	-0.045
Access to water source	0.127*	0.015	-.221***	-0.087
Treatment of water	0.058	-0.006	-0.072	0.019
Access to toilet	0.097	-0.015	-.230**	-0.07
Cleanliness condition of toilet	0.093	-0.132*	-.172**	-0.072
Wash hand after toilet	0.003	-0.125*	-0.081	-0.077
Wash hand before having food	-0.08	-0.015	-.188***	-0.091
Wash hand before cooking	-0.018	0.006	-.220**	-.149**
H_2S results	-	-0.112	-0.098	-0.02
Diarrhea	-	-	.288***	.337***
Fever	-	-	-	.407***

Discussion and Conclusion

We would argue that there is a considerable body of evidence to indicate that the households where the quality of water was better the morbidity conditions in those households were low whether it is a resettled and non resettled slum. Household taking water from public tanker truck was more affected by the faecal contamination of the water and more prone to water borne diseases. Source of water and access to water source (public or community water sources) was associated with diseases like fever and cough. Thus, we have found a strong association of poor water quality with the incidence of diseases whether it is resettled slum or non-resettled slum. Thus, the arguments put forward by VanDerslice and Briscoe (1993) may be valid under certain conditions, there are several scenarios imaginable where there is a strong probability that disease transmission will be the outcome of in-house water pollution due to supply handling and storage. It would be important to safeguard drinking water between collection and consumption. Household stored water might be one route by which new pathogens are introduced to the household along with the other several reasons like supply of water and handling practices. Social interaction and water and sanitation practices by children and adults alike will lead to the transmission of pathogens via water, food and physical contact (VanDerslice 1993). The dramatic increase in contamination after collection indicates the point at which the biggest health impact can be made is at the household level storage and handling. Studies have shown that households with contaminated stored water samples did not show significant differences in demographics, water handling, hygiene practices, or sanitation (Eschol et al. 2009). There are severe deficiencies in water-related health is found in despite of different socio economic status of localities. Mostly bacterial contamination of drinking water occurred due to post-source contamination during storage in the household, except during the monsoon season, when there was some point-of-source water contamination. This suggests that safe storage and household water treatment interventions may improve water quality in slums. Problems of excessive expense, inadequate quantity, and poor point-of-source quality can only be remedied by providing slums with equitable access to municipal water supplies (Subbaraman et al. 2013).Thus, attention must be given towards developing practical strategies to ensure safe drinking water, provided at the point of supply and consumption and practices towards water storage handling and consumption, No matter it is a resettled or a non resettled slum. As just providing people houses to live doesn't change their behavioural practices towards water, sanitation and hygiene .As per the study, the practice of households in the slums to store and consume unsafe drinking water remains the same even if they are given a proper place to live and have got resettled . Thus, improvement in practices related to safe drinking water supply storage and consumption is needed for any place of human habitation which will lead to reduction in water borne diseases and improved overall health.

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