



Effect of Solid and Polythene Wastes and Anthropogenic Activities on the Quantity and Flow of Water in Natural Freshwater Springs (dhara) in Nainital

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Abstract

Solid and polythene wastes are affecting directly to the natural freshwater ecosystem in almost all the hilly cities. Anthropogenic activities and poor management of these wastes may alarm the ecosystem services. Present study deals with the effects of generated solid wastes and polythene materials on the freshwater resources, in the city Nainital. Presence of these wastes sieges the flow of water in some natural springs and streams in the city. Approximately, 38 MT/day solid wastes are generated through different sources and it has been observed almost double during the tourist season (March to June). The presence of these wastes in and around the studied freshwater springs clearly indicates that it is not being handled or settled properly as it should be? Within the studied freshwater springs in the city, *Rajpura* freshwater springs was found most affected site by these wastes while spring at *Gufa Mahadeva* was observed as less affected site. Based on the collected data it has also been assumed that five major recharge zone of city has also been reduced their recharge capacity. During the suryes and discussion, majority of tourists and local people have been accepted that natural resources in the city has been affected badly with generated solid wastes as well as other anthropogenic activities, when asked during the field visits.

Introduction

The Himalayan mountain system is bestowed with the mountain springs (Xu *et al.*, 2009) which is a big source of freshwater to sustain the lives of millions of people. Climatic stresses and anthropogenic activities in these areas have been affecting badly to

the natural resources, consequently, natural water resources are facing a depleting phase as well as a big load of generated solid wastes. Somewhere, due to the poor management or improper handling, these waste materials are throwing directly into or near to the flow of water where these are spoiling the quality and quantity of water. Western countries witnessed the problem of water pollution due to the discharge of wastewater or waste materials into the natural water bodies in 19th century and also in India after independence (Singh and Singh, 2015). Natural freshwater resources like springs, streams and lakes have been affected and disturb the balance of water quality and quantity, by the human interferences somewhere directly or indirectly. Based on some recent reports it has been confirmed that 8,000 villages are facing an acute shortages of drinking water only due to the drying up of springs in the Himalayan region (Mahamuni and Kulkarni, 2012). Valdiya and Bartarya (1989), reported the 40% reduction in the stream discharge along with the permanent drying of 75% springs. Combinations of the bio-physical and socio-economic factor are responsible for the drying up of the springs in the Himalayas (ICIMOD, 2015). Presently, Himalayas are facing the challenges of tourism, deforestation, pollution, unplanned development, etc. (Xu *et al.*, 2009; Bawa *et al.*, 2010; Shrestha *et al.*, 2012; Kala, 2014; Kumar and Sah, 2016a). The fresh water springs and streams in the Himalayan region are under immense pressure due to the rapid urbanization and poor or improper management of generated solid wastes. Irrespective of the having proper municipal water supply, drinking water for several household is fulfilling by the freshwater springs and streams (locally known as dharas). Not only climatic challenges but human activities (especially improper management of generated solid wastes) have also been disturbed the originality and functioning of freshwater resources in the city Nainital, Kumaun Himalaya, Uttarakhand. Proper management of generated solid waste and polythene materials in and around the mountainous terrains has always been a bog problem (Kumar and Sah, 2015), while it is apparent to note that if springs and small seepage canals are managed properly in these areas, the scarcity of water could be averted (Vashisht, 2008).

Studies on the importance of the freshwater resources have been carried out earlier (Kelkar *et al.*, 2008; Drew, 2011; Chatterjee *et al.*, 2010; Tiwari and Joshi, 2012; Kala, 2014; Rasul, 2014) while the effects of solid waste and anthropogenic activities on the quantity and quality of freshwater resources is less emphasized. Therefore, the present investigation was carried out to study the effects of solid waste and polythene materials as well as anthropogenic activities on some freshwater resources in Nainital.

Materials and Methods

Study Area

Present study was conducted in and around Nainital (29°24'N and 79°28'E), a beautiful hill city in Kumaun Himalaya, Uttarakhand, India. The city is situated around a natural freshwater lake that allows growing a peculiar fauna and flora and the pleasant and peaceful climate of the city attracts the tourists worldwide.

Selection of springs and analyses

Personal surveys were made to visit the affected freshwater sources which were fully or partially dumped due to the hives of solid waste materials. Based upon the personal surveys in the areas and previously reports, total 13 natural springs in and around the city were selected. Flow rate of water in the studied springs was calculated by measuring the collecting volume of water in a fixed time. Plastic bucket and measuring cylinder were used to collect and measure the amount of collected water (as sample), respectively. Personal discussion and collected reports from the persons of Municipality and Lake Development authority, Nainital, were used to interpret the data.

Results and Discussion

The studied freshwater springs were found affected by the solid as well as polythene waste materials. It is observed also that wastes; including solid and others course materials, are being dumped not only to marked sites but also to the several unmark or common beautiful places in the city. Furthermore, people were found free and somewhere habitual to throw their wastes anywhere in the city as well as in or near to the running water sources. At some places it has also been observed that the thrown waste, mainly polythene materials has been created a critical condition and almost jammed the flow of naturally running water (Figure 1 DE). The studied freshwater springs (perennial and seasonal), also being used as a source of potable water were also found affected badly, out of them some may be at risk to lost the quantity and quality of water due to the continuous deposition of polythene and solid wastes (Figure 1 ABCDEF; Table 1). The maximum effect of waste was found on Rajpura (RJ) site while Gufa Mahadev (GM) was found less affected by these wastes (Table 1). As, the flow of water was found reduced to 2.50% to 73.435 at the sites Gufa Mahadev and Rajpura, respectively (Table 1).



Figure 1 Effect of generated solid and polythene wastes on the water resources, clearly showing the blockage in water flow.

Table 1. Reduced rate of water flow at studied springs in Nainital

S. No.	Name	Position	Status	Average flow /minute (in past)	Average flow /minute (in present)	% Reduction
1	Spring Field (SF)	29°23'41 ^{nl} 79°26'55 ^{el}	Perennial	1500 ml	650 ml	56.66
2	Chuna Dhara (CH)	29°23'41 ^{nl} 79°26'55 ^{el}	Perennial	6000 ml	5500 ml	8.33
3	Spring Field Cottage (SF)	29°23'44 ^{nl} 79°27'20 ^{el}	Perennial	3500 ml	1500 ml	57.14
4	Rajpura (RJ)	29°23'22 ^{nl} 79°27'21 ^{el}	Perennial	32000 ml	8500 ml	73.43
5	Lake View (LV)	29°23'18 ^{nl} 79°27'20 ^{el}	Perennial	4000 ml	1200 ml	70.00
6	Mount Rose (MR)	29°23'18 ^{nl} 79°27'20 ^{el}	Perennial	8000 ml	5000 ml	37.50
7	Bhabar Hall (BH)		Perennial	Not measurable	Not measurable	-
8	Parda Dhara (PD)		Perennial	43000 ml	40000 ml	6.97
9	Shuk Nivish (SN)	29°23'21 ^{nl} 79°27'30 ^{el}	Perennial	2500 ml	1500 ml	40.00
10	Sher ka muh (SH)	29°22'41 ^{nl} 79°28'19 ^{el}	Perennial	3500 ml	3200 ml	8.57
11	Do Pipe (DP)	29°22'41 ^{nl} 79°28'19 ^{el}	Perennial	4000 ml	1400 ml	65.00
12	Sipahi Dhara (SD)		Perennial	122000 ml	82000 ml	32.78
13	Gufa Mahdev (GM)	29°22'16 ^{nl} 79°27'18 ^{el}	Perennial	20000 ml	15000 ml	2.50

Data summarized in table 1, clearly indicates the effects of solid and polythene wastes on the freshwater resources. Out of total 13 studied sites, the Rajpura (RJ) spring was found to be maximum affected (73.44%) site while Gufa Mahadev (GM) was observed as minimum affected (2.50%) site. Approximately, 38 MT/day (Table 2) of solid waste is generated in the city through different sources but it is important to mention here that the quantity of waste has been estimated almost double in the tourist season *i.e* around 70 to 75 MT/day. Based on the personal discussion, it has also been found that the collection of wastes during the main tourist season (March to June) become tedious then these wastes might be run with the flow of water during rainy season and slowly by slowly deposited near to the water reservoir. It has also been observed also that the presence of polythene materials into the running water sources creating a critical condition in normal flow of water due to the less-biodegradability of these materials (Singh and Singh, 2012). Furthermore, the construction processes in the

hilly areas may also left behind a countable amount of waste materials that might be flow with rain water (Figure 1 F) and deposited or settled near to the studied sites (Figure 1 C), during the rainy season. The degradation of industrial wastes, especially textile and leather wastes is major problems to the environment in the plane areas (Singh and Singh, 2017) while the settlement or handling for solid waste is a new challenge in the hilly region (Chatterjee *et al.*, 2010). Generally, the cold climate at hill station allows only a special class of microbes to degrade the waste materials. Several fungal strains have been isolated (Singh and Singh, 2010a,b) to degrade the textile effluents (including synthetic dyes) that may be culture to test the degradation of these wastes in hilly areas to promote the natural degradation of xenobiotics.

Table 2. Waste generated through different sources in Nainital

Description of wastes	Shops/Hotels	Per Capita Waste	Unit	Total Waste
From residential population	50,417	0.25	Kg/capita/day	12604.15
Hotel waste	9,653	1	Kg/room	9652.50
Restaurant waste	165	5	Kg/restaurant/day	825
Institutional/administrative waste	6,760	0.1	Kg/capita/day	676
Market area waste	650	1	Kg/establishments/day	650
Waste generated by tourists (day time)	25,138	0.05	Kg/capita/day	1256.9
Waste generated by tourists (night time)	37,812	0.25	Kg/capita/day	9,453.11
Street Sweepings	50,417	0.05	Kg/capita/day	2520.83
Total Waste				37638.49
Approximately estimation				38 MT

Source: From executive summary of Nagar Palika Parishad, Nainital 2015-2016

The disturbed water quality and quantity in any natural ecosystem may be an indicator of the pressure or load of anthropogenic activities, in the area. The five major recharge zones *Sukhatal*, *Oak Park*, *Sleepy Hollow*, *Dalhausi Villa* and *Sher Wood* are considered as life line of the Naini lake that have also been reduced their capacity to recharge the lake and the catchment, including locally known 'dhara' or freshwater sources (Figure 2). The lake in Nainital is subjected to sedimentation that might be due to the deposition of solid waste, generated in the city. Although, climatic challenges are common in the hilly areas but the lost capacity of water resources might also be due the

disturbances, either directly through the developmental processes or indirectly by other anthropogenic activities of human.

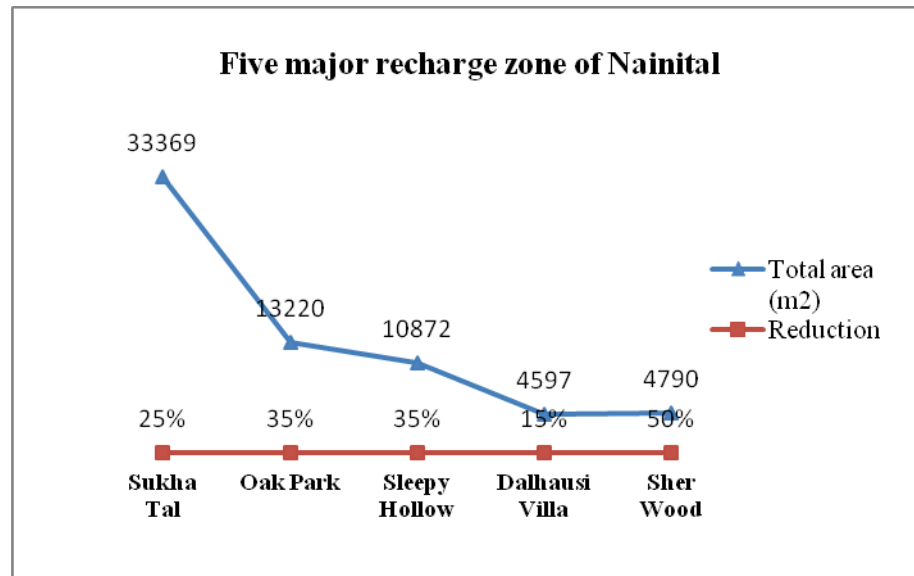


Figure 2 Reduction in the recharge capacity of five major reservoirs in the Nainital
(Source: From executive summary of Nagar Palika Parishad, Nainital 2015-2016)

Anthropogenic activities and rapid urbanization in the mountainous cities might have changed or disturbed the natural ecosystem somewhere in these areas, resulted a direct loses in the quantity and quality of potable water as well as aquatic fauna and flora (Kumar and Sah, 2016b; Singh and Sati, 2014) and dependent wild life animals. Nainital is a familiar tourist spot having a load of tourists and visitors and face a load of increased waste materials, during the tourist season (Table 2). Though, several connection have been improved considerably but still the majority of wastes from the bathroom are going directly into some freshwater sources that may affect to the decomposer community of natural ecosystem that play an important role by decomposing the wastes in aquatic ecosystem (Singh and Sati, 2014).

Solid waste management in the hilly cities is a big task now a day. Scientists and policy makers should be on the same table to save and sustain the natural ecosystem. Although, several groups of researchers worldwide are involved to find out the way for the proper management of solid and polythene wastes but natural degradation of these xenobiotics using some selected microbial strains would be a better option for the degradation of wastes that may also be helpful to sustain the natural ecosystem in these areas.

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Authors' contributions: Hardesh Sharma and Lokendra Singh surveyed the freshwater springs and collected the samples and sites photographs during the field study. Hardesh Sharma also arranged the meeting and discussed with the persons of concerned authority to collect the reports on the topic. B. L. Sah designed the experiment and helps to provide the necessary facilities during research and field surveys. Lokendra Singh corresponding author wrote and communicated the manuscript.

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