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Evaluation of ground water quality near Chandi Devi bridge solid waste dumping site at Hairdwar city, (Uttarakhand), India : A case study

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Abstract
The present study observed groundwater quality around Chandi Devi bridge open dumping site at Hardwar (Uttarakhand), India. Five experimental sites viz. sites 2,3 and 5 (hand pumps) and two sites 4,6 (tubewells) within the vicinity of the dumpsite and a reference site viz. site 1 (hand pump) (Bilkeshwar temple) as a control about 5000 meter away, were selected to ascertain the influence of solid waste dumping on groundwater quality around the area. The study showed that physicochemical parameters viz temperature, colour, turbidity, pH, hardness, BOD, COD, fluoride and heavy metals (lead and iron) of the ground water near the dumping sites-2,3,4,5,6 were higher than their counterpart parameters of the ground water at control site. However, arsenic was not detected in any sample of all the sites. The parameters viz., colour (2.08-3.49 hazen), turbidity (3.05-5.35 NTU), odour (agreeable), pH (7.46-7.80),fluoride (0.10-0.38 ppm), lead (0.00-0.032 ppm), iron (0.01-0.03 ppm) of ground water of all experimental sites were within permissible limits while the parameters BOD (3.73-3.21 ppm), hardness (240.41-203.15 ppm) at site-2, site-3 and DO (5.38-6.28 ppm) of all experimental sites were not found within permissible limits as prescribed by Bureau of Indian standards (2012). Although water was safe for drinking which may be due to higher infiltration rate of river Ganga and Eastern Ganga Canal water but higher value of temperature (^{o}C), colour (hazen), turbidity (ppm), hardness (ppm), BOD (ppm), COD (ppm) fluoride (ppm), iron (ppm) and lead (ppm) at site- 2 was quite alarming. The study would help in making public awareness for waste sorting, adopting green technology and to predict level of contaminants in ground water produced by land filling dumping site.

Keywords: Ground water, Chandighat duumping site, Haridwar, Heavy metals, Physico-chemical parameters

INTRODUCTION

Ground water is a precious renewable natural resource, which has been exploited by man since centuries and is considered to be least polluted as compared to other inland water resource. Now in the era of economic growth ground water is becoming contaminated with hazardous substances from thousands of legally and illegally constructed and operated landfills surface impoundments in septic systems. As an advent of population growth and climate change, presently in most countries more than half of the extracted groundwater is used for meeting domestic needs, whereas globally 25%–40% is used as drinking water indicating that the demand for clean groundwater has already grown dramatically (NGSA, 2016).

Landfills have been identified as one of the major threats to groundwater resources. Areas near landfills have a greater possibility of groundwater contamination because of the potential pollution source of leachates originating from nearby sites Berner and Berner (1987) and CPCB (2015). The leachates when mixed with water body increase the concentration of heavy metals, nitrates, sulphates and other organic and inorganic substances. Anthropogenic pollution includes the presence of either heavy metals (arsenic, chromium, cadmium, cobalt, manganese, zinc, copper, mercury etc.) or persistent organic pollutants (POPs), volatile organic compounds, petroleum hydrocarbons, dyes and pigments, insecticides and herbicides, pharmaceutical compounds, organohalides etc.) compounds in groundwater as a result of inappropriate waste management and disposal practices (Dermatas and Panagiotakis, 2012). Geogenic groundwater pollution for arsenic contamination problem in India and Bangladesh, or the hexavalent chromium contamination in California, Italy, Greece, and elsewhere, is exclusively related to the geochemical background of rock and soil, which feeds groundwater with heavy metals and these are capable of posing significant adverse effects to humans and environment (Dermatas *et al.,* 2015). In biotic perspective, heavy metals enter into living organisms through food, water or frequent contact to emission sources, though few of them serve as vital micro nutrients for living beings but at higher concentration it can lead to severe poisoning (Lenntech 2004). In recent past, Soujanya and Kamble (2016) showed characterization of leachate and its effects on ground water quality at Telangana in India and Karthika *et al.* (2018) studied the ground water quality near industrial area sites at Tamilnadu and Krcmar, *et al.* (2018) studied the effect of municipal landfill pollution on soil and shallow groundwater in Subotica, Serbia. The present study was undertaken to analyze effect of waste-disposal on the groundwater quality of the area near Chandi Devi bridge solid waste dumping site at Hairdwar city (Uttarakhand), India.

MATERIALS AND METHODS

Study area: Hardwar is a holy place located at 29°56′52″N78°09′36″E where people come not only from India but also from abroad to perform various socio-religious rituals almost throughout the year. The total population of Hardwar city is 2,28,832 as per 2011 census (www.census2011.co.in/city.php) having a city area 2,360 km^2.The population of Hardwar city get increased during the Hindus' festivals time by tourist and pilgrims who left bulk amount of municipal waste here. The central Hardwar area (Harki pauri to Kankhal) always remained packed with the tourist and generated waste was being dumped near Chandi bridge municipal dumping site which extended towards N-W direction of Chandi bridge. The area of Experimental sites covered approx. 20000 mt^2. Sites-2, 3, 5 (Handpump water) and sites-4, 6 (tubewell water) were selected as Experimental sites and Bilkeshawar temple (Handpump) was selected as control site. Site-2 water source was located in S-E direction and 60 mt far from dumping area. Site-3 was located in south direction and 122 mt. far. Site-4 was located in S-E direction and 91 mt. far, Site-5 was in south direction and 240 mt. far. Site-6 was located in south direction and 260 mt. far from the dumping site. The control site (site-1 Bilkeshwar temple) was located S-E direction and 5000 meter far from the experimental sites (Fig.1).

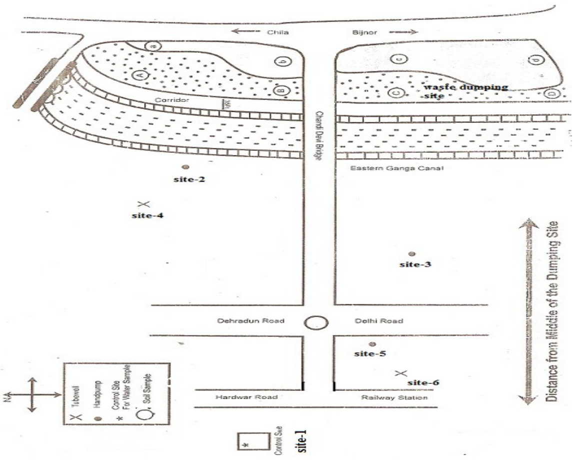

Fig. 1. *Study area showing different sampling sites of groundwater near Chandi Devi bridge dumping area and control site (near Bilkeshwar temple), Haridwar city (Uttrakhand).*

Methodology: The ground water samples (500ml.) were collected from the sources (4 hand pumps and 2 tube wells) in plastic canes from the area of dumping site during 2005-2007 from January to December by avoiding sampling during rainfall period. At a time four water samples were taken monthly from each site i.e (4×6=24 samples) for analysis . Some of the parameters were determined immediately at sampling sites viz. temperature (^{o}C), pH while for dissolved oxygen (ppm) and biochemical oxygen demand (ppm), samples were collected in 300 ml sterilized BOD bottles. The bottles were filled completely with sample water up to the rim and stopper was placed to avoid any kind of air bubble inside it. DO was immediately fixed by adding 2 ml alkaline potassium iodide and manganese sulphate ($MnSO_4$) at sampling spot. While the sample for BOD was incubated for 5 days in BOD incubator at 20^{0}C in the laboratory. For rest parameters like colour (hazen), turbidity (NTU), odour, hardness (ppm), fluoride (ppm), standard methods were used as per APHA (2005). The samples of groundwater for the analysis of heavy metals (arsenic, lead, iron) were stored in refrigerator at 4°C and acidified with concentrated HNO_3 (5 ml/l ml of water sample to reduce the pH of the sample, pH > 2.0). The total metal contents were determined by digesting 200 ml of sample with a mixture of concentrated HNO_3 and $HClO_4$ acid (10 ml + 2 ml). The digested samples were filtered through Whatman filter No. 42 and final volume was made 10 ml with 0.1 N HNO_3 and analyzed for heavy metals using AAS (Model ECIL-4129) using the method as prescribed by APHA (2005).

RESULTS AND DISCUSSION

The physicochemical parameters of the ground water quality of different sites (site-2 to site-6) of Chandidevi bridge dumping site and that of con-

Table 1. Physico-chemical parameters of groundwater in and around Chandi Devi bridge dumping area of Haridwar city (Uttarakhand).

Parameters	*Site-1 (HP)	Site -2 (HP)	Site -3 (HP)	Site -4 (TW)	Site -5 (HP)	Site -6(TW)	BIS, 2012	
							Acceptable limit	Permissible limit
Temperature (^{O}C)	16.37 ± 1.10	23.13 ± 1.04	22.92 ± 1.03	22.14 ± 1.03	21.34 ± 0.83	20.91 ± 0.86		
Colour (hazen)	2.08 ±0 .56	3.49 ± 1.12	3.29 ± 1.11	2.71 ± 0.75	3.06 ± 0.98	2.42 ± 0.64	5.00	15.00
Turbidity (NTU)	3.05 ± 1.22	5.35 ± 1.80	5.12 ± 1.75	4.57 ± 1.51	4.03 ± 1.23	3.78 ± 1.15	1.00	5.00
Odour	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	No relaxation
pH	7.46 ± 0.27	7.80 ± 0.20	7.71 ±0.15	7.71 ± 0.21	7.58 ± 0.22	7.53 ± 0.24	6.5-8.5	No relaxation
Hardness (ppm)	138.65 ± 29.78	240.41 ± 92.05	203.15 ± 73.81	146.62 ± 36.10	142.97 ± 31.13	141.61 ± 31.51	200.00	600.00
DO (ppm)	6.28±0.67	5.38 ±0.95	5.43 ± 0.96	5.97 ± 0.73	6.04 ± 0.76	6.10 ± 0.67	8.00	4.00
BOD (ppm) (5DAY 20^{o}C)	1.67±0.54	3.73 ± 0.97	3.21 ± 0.62	2.78 ± 0.65	2.35 ± 0.54	2.22 ± 0.54	-	3.00
COD (ppm)	14.21±2.66	31.61 ± 6.66	20.46 ± 2.51	18.40 ± 2.12	19.23 ± 1.95	17.53 ± 2.35	-	
Fluoride (ppm)	0.1±0.04	0.38 ± 0.11	0.30 ± 0.13	0.25 ± 0.11	0.18 ± 0.08	0.12 ± 0.04	1.00	1.50
Arsenic (ppm)	BDL	BDL	BDL	BDL	BDL	BDL	0.01	0.05
Lead (ppm)	BDL	0.032 ± 0.01	0.006 ± 0.002	0.004 ± 0.002	0.003 ±0.002	BDL	0.01	No relaxation
Iron (ppm)	0.01 ± 0.01	0.03 ± 0.02	0.02 ± 0.02	0.02 ± 0.01	0.01 ± 0.01	0.01 ± 0.01	0.30	No relaxation

*-Control; HP-Hand pump; TW-Tubebell; BIS-Bureau of Indian Standards of Drinking water; BDL-Below detection limit

Table 2. Showing correlation coefficient (r) values among various physico-chemical parameters of groundwater.

Parameters	Temp.	Colour	Turbidity	Odor	pH	Hardness	DO	BOD	COD	F	As	Pb	Fe
Temp	1.000												
Colour	0.690	1.000											
Turbidity	0.862	0.323	1.000										
Odour	0.000	0.000	0.000	1.000									
pH	0.837	0.401	0.874	0	1.000								
Hardness	0.795	0.346	0.868	0	0.762	1.000							
DO	-0.973	-0.587	-0.910	0	-0.918	-0.853	1.000						
BOD	0.964	0.706	0.877	0	0.823	0.792	-0.958	1.000					
COD	0.605	0.971	0.250	0	0.331	0.275	-0.503	0.649	1.000				
F	0.588	0.962	0.230	0	0.233	0.314	-0.476	0.629	0.944	1.000			
As	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.000		
Pb	0.944	0.644	0.844	0	0.871	0.871	-0.967	0.945	0.587	0.564	0.000	1.000	
Fe	0.864	0.632	0.807	0	0.708	0.933	-0.873	0.879	0.559	0.618	0.000	0.903	1.000

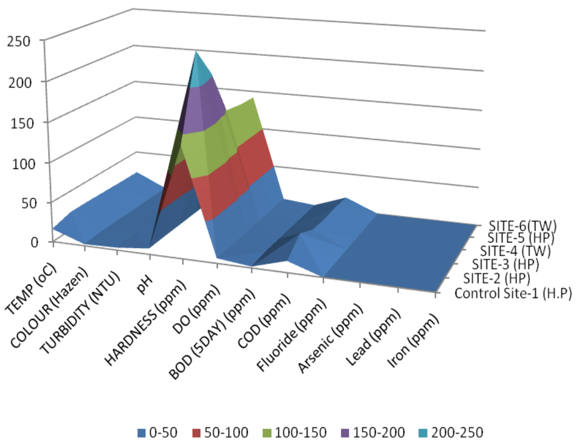

Fig. 2. *Showing variations among physicochemical parameters of ground water of different sites of Chandi bridge and the control site (near Bilkeshwar temple).*

trol (site 1) are given in Table-1 and the correlation (r) values among different parameters are shown in Table-2. Fig.2 shows variations among physicochemical parameters of ground water samples of different sites.

Temperature: Its measurement is useful to determine the trends of biochemical and biological activities in aquatic ecosystem. The growth of organisms and microorganisms are enhanced by warm water conditions and can lead to the development of unpleasant taste and odour (Sacramento, 1963). While Lalitha *et al.*, (2003) studied that the temperature of water ranging from 7 °C to 11 °C is pleasant and refreshing in nature and Edo *et al.* (2014) reported temperature of ground water in the range of 26 - 26.90 °C in Igwuruta at Nigeria. In the present study it was observed that the ground water of all the experimental sites had higher temperature value (20.91 to 23.13 °C) than control site (16.37 °C) bilkeshwar temple. The site -2 had higher temperature (23.13 °C) among all experimental sites which may be due to higher pollutant load at this site. The correlation (r) among different parameters with the temperature showed that temperature was negatively correlated with DO (-0.973). The increase in temperature increases the dissociation of oxygen and increases the growth of microorganism which also consumes the oxygen for their survival. Therefore, the municipal waste dumping may have a negative effect on the temperature of ground water.

Colour: It is the onsite indicator for potability of water and may result from the presence of natural metallic ions (iron and manganese). Royee and Prakasam (2003) observed higher range (12.5 hazen to 15 hazen) of colour in tube well water at Kollam municipality, Kerala, while Mahesha and Prasad (2004) noticed the lower range (1.3 hazen to 4.0 hazen) of colour near Arsikere Taluk at Karnataka than the present studied values of colour (2.42 to 3.49 hazen) in ground water of all the experimental sites. Although the observed range of colour was under the desirable range of BIS but mean value at site-2 (3.49 hazen) was quite higher and may cross the desirable limit in future. This may be due to presence of higher dissolved organic matter and salt concentration in the ground water at experimental sites, which might have increased the hardness as well as turbidity, thereby increasing the colour.

The correlation coefficient (r)among different parameters with the colour showed that colour was positively correlated with temperature (+0.690) and pH (+0.401) at experimental sites. Andrew (1995) stated that the colour of water is extremely pH dependent and invariably increases as the pH of water is raised. The positive correlation of colour with temperature showed that as the temperature increased, the microbial decomposition of organic material might also increase thereby increasing the colour of the ground water. Thus, the municipal waste may influence the colour of ground water adversely.

Turbidity: Roy (2004) observed the turbidity of water ranging from 0.4 NTU to 5.6 NTU near NCC office at Kollam Municipality, Kerala, while Deshpande *et al.* (2005) found the range of turbidity (4.6 NTU to 6.5 NTU) at Ramtek Tehsil, Nagpur. Sahni *et al.* (2010) reported higher value of turbidity which may be due to leaching of toxic substances of municipal solid waste into the ground water. Mishra *et al.* (2013) reported higher turbidity range from 9.6 to 32.8 NTU in Jharpada and other sites at Odisha. In the present study it was observed that the experimental sites had higher turbidity value (3.78 to 5.35 NTU) than the control site (3.05 NTU) bilkeshwar temple which may be due to higher degree of precipitates of Ca and Mg. The detected range of turbidity were under the desirable limit of BIS It may due to presence of organic material coming from the leaching of the waste which not only increases the turbidity but also affect the other parameters.

The presence of higher suspended impurities in ground water at site-2 may due to less distance from dumping site and higher leaching of soluble impurities from waste. These impurities proliferate downwards and remain on the superficial layer of water. Therefore, it may be said that higher dumping of municipal waste also has a detrimental effect on turbidity of ground water.

The correlation study revealed that turbidity was directly proportional to the suspended and dissolved solids present in ground water which may absorb and reflect the light back to the surrounding thereby interfering the movement of light and affects the colour of water positively (r=+0.323).

Odour: The odour may be of natural origin caused by living and decaying aquatic organisms and accumulation of gasses like ammonia and hydrogen sulphide (Asthana and Asthana, 2004). In the present study, odour was unobjectionable at all the experimental dumping sites of Chandi bridge, Hardwar which may be due to higher dilution from surface water body.

pH (Hydrogen ion concentration): pH plays an important role in the growth of microbial activity. As specific microorganism carryout optimum activity related with degradation of organic components in a particular range of pH and change in pH may adversely affect microbial activity of that particular aquatic ecosystem. Govardhan (1990) observed the pH range of ground water 6.2 to 8.9 in Nalgonda at Telangana. Mohammad *et al.* (2002) reported that pH tends to increase from summer to winter which may be due to depletion in readily biodegradable organics in ground water. Royee and Prakasam (2003) observed the pH range 7.36 to 7.49 in tube well water near Kollam Municipality at Kerala. Panda *et al.* (2004) found the basic pH range (7.1 to 8.1) in wet season at garbage dumping site of Palasuni villge and other places at Bhuvaneswar. The present study also observed that the experimental sites had higher and basic range of pH (7.53 to 7.80) than control site (7.46) which may be due to presence of more salts in the water at experimental sites .The studied values of pH are within desirable range of BIS. Almost similar value of pH has been detected by Gautam *et al*. (2011) at municipal waste dumping site Sewapura at Jaipur. The present study revealed that basic range of ground water at experimental sites might be due to presence of anions like OH^{-},$CO3^{--}$ and $HCO3^{-}$ which are also responsible for higher alkalinity of ground water.

Yadav and Lata (2003) have noticed the positive correlation in between pH and electrical conductivity at Bahadurgarh block Jhajjar, Haryana. In the present study correlation coefficient (r) among different parameters with the pH showed that pH was positively correlated with turbidity (+0.874). It may due to that at the basic pH, the salts or the anions increase with the result the turbidity and electrical conductivity of ground water also increases. Therefore, the dumping of municipal waste may increase the pH of water and helps to change the taste of ground water.

Total hardness: Subba Rao (1998) observed that higher values of Ca and Mg have a positive impact on eutrophication in ground water (well water). Panda *et al.* (2004) observed the higher value of calcium and magnesium species in wet season than the summer. Mahesha and Prasad (2004) observed slightly lower hardness (range 170 to 410 mg/l) near Arsikere at Karnataka. Deshpande *et al.* (2005) noticed hardness range 264 ppm to 319 ppm at Ramtek Tehsil, Nagpur. Kurakalva *et al.* (2016) found higher value of total hardness (TH) of groundwater samples from 120 to 525 mg/L at Jawaharnagar municipal solid waste dumping site at greater Hyderabad. In the present study the total hardness of all experimental sites were within the desirable range of BIS but it was observed that the experimental sites had higher total hardness (141.61 to 240.41 ppm) than control site (138.65 ppm) which may be due to leaching of higher Ca and Mg species from waste affected soil in the ground water of the experimental sites. The Ca and Mg species increase due to contamination of acidic leachate when the leachate reacts with soil having abundant calcium and magnesium. The cations tend to move with leachate and reaches in to the ground water. This mechanism enhances the formation of carbonates of Ca and Mg in ground water thereby increasing the hardness of ground water. Taste of water is also dependent upon the presence of Ca^{++} rather than Mg^{++}. The correlation among different parameters with the hardness showed that hardness was positively correlated with pH (r=+0.762) and turbidity (+0.874) at all the experimental sites. The hardness of ground water increased as the turbidity increased. It may be due to higher precipitation of Ca and Mg carbonates in soil that leached to the ground water and increased the hardness of water.

Dissolved oxygen (DO): Sangodoyin and Agbawhe (1992) reported DO values ranging from 5.1 to 5.6 ppm in well water near the dumping site of Abattoir effluents at Ibadan, Nigeria. Mahesha and Prasad (2004) observed DO range (6.22 to 6.48 ppm) of bore well water at Arsikere taluk, Karnataka. Edo *et al.* (2014) noticed DO in the range of 5.20 to 6.30 ppm in Igwuruta at Nigeria. In the present study the values of DO at all experimental sites did not match the desirable limits of BIS. The experimental sites had lower DO range from 5.38 to 6.1 ppm than control site (6.28 ppm) which may be due to presence of higher oxygen consuming ingredients in the ground water at experimental sites. It may due to presence of higher organic and biological load in ground water which may be released from the leachate of degradable waste thereby decreasing the DO value of ground water at solid waste dumping site.

The correlation coefficient (r) among different parameters with the DO showed that DO was negatively correlated with temperature (r=-0.973) and turbidity (-0.910) at all the experimental sites. This may be due to an increase in temperature which increases the dissociation of oxygen and increases the growth of microorganisms that also consume the oxygen for their survival. The higher amount of organic matter, silt and Ca/Mg increases the turbidity of ground water thereby decreasing the DO value by consuming most of its part during their stabilization. Thus, it may be said that higher dumping of municipal waste decreased the DO level in ground water which may be harmful for aquatic life and may produce obnoxious odour.

BOD: Mahesha and Prasad (2004) observed higher range of BOD (4 to 5 ppm) at Hasan, Karnataka. Edo *et al.* (2014) reported BOD range from 1.20 to 4.6 ppm in Igwuruta at Nigeria. The present study observed that the values of BOD at experimental site-2 and site-3 were quite higher than permissible range of BIS while rest experimental sites were within permissible range of BIS. All the experimental sites had higher BOD (2.22 to 3.73ppm) than control site (1.67 ppm) which may be due to presence of organic impurities in ground water which requires more oxygen in its decomposition by aerobic bacteria. The aerobes may decompose the organic matter and utilize most of the dissolved oxygen. These organic impurities may easily enter into ground water with leachate, originated from solid waste dumping site thereby increasing the BOD of ground water during their microbial decomposition.

The correlation among different parameters with the BOD showed that BOD was negatively correlated with DO (r=-0.958) and positively correlated with the temperature (r=+0.964) at all the experimental sites. This study showed as the microbial population increased, the temperature also increased and enhanced the degradation of organic matter present in ground water near solid waste dumping site.

COD: Aurangabadkar *et al.* (2001) observed the range of COD (12 to 40 mg/l) near Perungudi dumpsite at Chennai while Ikem *et al.* (2002) observed the lower value (0.62 ppm) in dry season and (6.03 ppm) in rainy season near Ibadan, Nigeria. Edo *et al.* (2014) noticed lower range of COD (2.10 to 7ppm) in Igwuruta at Nigeria. In the present study it was observed that the experimental sites had higher COD value (17.53 to 31.61ppm) than control site (14.21 ppm), which may be due to presence of organic impurities in ground water. It may be due to acidic nature of rain water that have higher solubility of inorganic and organic impurities present at dumping soil and also lesser density of soil particles through which these impurities percolates and reaches to ground water increases the COD value of ground water and ultimately decrease the DO present in ground water and may affect its portability.

The correlation coefficient (r) among different parameters with the COD showed that COD was positively correlated with colour (r=+0.971) and negatively correlated with the DO (r=-0.503) at all the experimental sites. The presence of higher amount of inorganic and organic compounds in ground water near solid waste dumping site which may increase the colour and affect the COD value. The consequences of increase in COD value result in downfall of DO thereby showing negative correlation of COD with the DO and positive correlation with the colour gradient of ground water.

Fluoride: Occurrence of fluoride has drawn worldwide attention due to considerable impact on human physiology (Kundu et al. 2001). About 115.3 lakh Indian population is at risk based on population in habitations with high fluoride in drinking water (DGHS, 2016). Royee and Prakasam (2003) observed slightly higher fluoride range of 0.66 to 0.72 ppm at Kollam municipality, Kerala. Kumar *et al.* (2015) has observed higher Fluoride (0.56 to 0.76 mg/l) during pre-monsoon and from 0.44 to 0.88 mg/l during post monsoon at Thiruvananthapuram. The present study showed that though fluoride content at all experimental sites were within desirable range of BIS, the experimental sites had higher fluoride value (0.12 to 0.38 ppm) than control site (0.1 ppm) which may be due to presence of fluoride contamination from percolation of leachate. This leachate may be enriched with fluoride due to dumping of cloth products having dyes and coloring agents .These cloth articles are highly demanded during festival season of *Kanvar* yatra during of Mahashivratri in Haridwar. The correlation coefficient (r) among different parameters with the fluoride content showed that fluoride was negatively correlated with DO (r=-0.476) and positively correlated with the COD (r=+0.944) and temperature (r=+0.588) at all the experimental sites. The correlation study gave a clear indication that fluoride was directly proportional to temperature and COD while inversely proportional to DO. As the temperature increased, the formation of oxides, other constituents of fluoride may also be increased. During this process, the COD value showed sharp increase and DO value showed sharp downfall because the oxides formation may consume most of the D.O Thus the presence of more fluoride in ground water may have increased the C.O.D of water.

Arsenic: It has a tendency to get accumulated in body tissue to cause arsenosis and may have an adverse effect on liver, heart, and is also reported as carcinogenic (Saha *et al.,*2010), Arsenic has been associated with a variety of complications in body organ systems that may be integumentary, nervous, respiratory, cardiovascular, hematopoietic, immune, endocrine, hepatic, renal, reproductive system (Khaja et al., 2015) As per the WHO the maximum permissible limit of arsenic in ground water is 0.05 mg/L. In the present observation, arsenic (0.00 ppm) was not detected and thus did not influence the water quality significantly.

Lead: It is also a toxic element and accumulates in the body mainly in the bones. Chronic exposure of lead can result in mental retardation, birth defects, psychosis, autism, allergies, dyslexia, weight loss, hyperactivity, paralysis, muscular weakness, brain damage, kidney damage and may even cause death (Martin and Griswold, 2009). Aurangabadkar *et al.* (2001) observed the lead range 0.05-0.06 ppm at west of

Perungudi dumpsite at Chennai and Ikem *et al.* (2002) noticed the lower range of lead (0.01to 0.03 ppm) in ground water at Ibadan, Nigeria. Lower value of lead was also observed by Patil *et al.* (2013) at Karnataka and quite the same value of lead has been detected by Edo *et al.* (2014) in Igwuruta at Nigeria. The present observation also showed lower range of lead at all experimental sites as per BIS and the values were within the permissible range. However, it was also observed that all experimental sites had higher lead content (0.000 to 0.032 ppm) than the control site (0.000 ppm) Bilkeshwar temple which may be due to the presence of paint remains in leachate coming from printed articles which are generally used in various festivals and its trash reached to disposal sites. The correlation coefficient (r) among different parameters with the lead content showed that lead was positively correlated with temperature (r=+0.944) and with COD (r=+0.587) at all the experimental sites. The correlation study gave an indication that lead was directly proportional to temperature and COD as the temperature of ground water increased the lead content also increases and thereby consuming more oxygen in stabilization and increasing the COD value of ground water. This may be due to disposal of discarded batteries that may have increased the leaching of lead towards ground water. Therefore, the dumping of municipal waste increases the lead content in ground water, which may pose serious health hazards.

Iron: Iron in ground water is often noticeably orange in colour, causing discoloration of laundry and has an unpleasant taste. Aurangabadkar *et al.* (2001) observed the iron content (range 0.6 to 3.86 ppm) near Perungudi at Chennai while Ikem *et al.*(2002) noticed iron range (1.05 to 4.6 ppm) at Ibadan, Nigeria. Edo *et al.* (2014) noticed iron range (2.00 to 4.40 ppm) Igwuruta at Nigeria. Panda *et al.* (2004) observed the value of iron ranged from 0.09 to 2 ppm during dry season in ground water sample of Palasuni village at Bhubaneswar city. Shenbagarani (2013) reported quite same range of iron (0.01 - 1.5 ppm) in ground water sample of Perungudi and Kodunganyur at Chennai Tamilnadu. The present study observed that iron content at all experimental sites were within permissible range of BIS. This study indicates that all experimental sites had higher iron content (0.01 to 0.03 ppm) than control site (0.01 ppm) which may be due to presence of Iron bacteria which helps to oxidize ferrous salts present in ground water in to ferric salts that also reduces oxygen condition and makes anodic region in iron pipes while exposed region act as cathodic region this phenomenon corrodes iron pipes, used in bore well and hand pumps. Although Fe^{++} is generally not harmful for living species but Fe^{+++} is poisonous for living species. Also these cations deposited on the clothes material and may be responsible for destruction of textile fiber. Iron bacteria also help to produce slime on the wall of water storage structure. The correlation coefficient (r) among different parameters with the iron content showed that iron was positively correlated with temperature (r=+0.864) and turbidity (r=+0.807) at all the experimental sites. The correlation study gave a clear indication that iron is directly proportional to temperature and turbidity. This may be due to higher salts concentration which may enhance the rust formation and thus increasing the iron content and turbidity in ground water samples by dumping of municipal waste.

The data analysis further revealed that in the present study, DO was found to increase while BOD and COD decreased as the distance of water source increased from dumping site (Fig.-2). DO was comparatively higher while BOD and COD were lower in tubewell water than handpump water due difference in the depth of both the water sources. This indicated the availability of more pollutants on the upper surface of ground water that affected ground water quality of hand pump more than the ground water quality of tubewell. The lower range of fluoride indicated that the fluoride content is also affected by dilution of surface water body running near to the dumping area. The presence of these anions indicated that these charges cannot be trapped by soil sediments and proliferate through leachate and enter in to ground water. The lower range of lead and iron content in ground water samples revealed low availability of lead and iron trash in municipal waste sites as these metals are economically important and picked by ragpickers from the dumping site. However, the higher concentration of lead and iron at the site-2 may be due to that it was closer to dumping area and the pollutants may increase here with an alarming rate.

Conclusion

In was concluded that groundwater quality of the areas around municipal waste dumping site (Sites 2 to Sites 6 of Chandi bridge, Haridwar city (Uttarakhand) , had higher values of the physico-chemical parameters viz. turbidity, pH, hardness, BOD, COD, fluoride, lead and iron than the area taken as control site-1. The waste disposal source was dominated over in the vicinity of Site-2 resulting in higher values of parameters viz temperature, colour, turbidity, pH, hardness, BOD, COD, fluoride, lead and iron than the other dumping sites. The higher COD value of site-2 showed presence of higher chemical impurities in ground water quality. Therefore ground water of site-2 is more contaminated than other experimental sites. The heavy metals (arsenic, lead, iron) and other parameters like temperature, colour, pH, hardness, fluoride except turbidity of site-2, 3 and DO, BOD in all the ground water samples were found within the permissible limits of BIS and may be considered safe for drinking purpose which may due to higher infiltration rate of water from nearby surface water source, river Ganga and eastern Ganga canal. This infiltration may have positive effect on dilution of polluted ground water that makes ground water fit for drinking purpose. The present study would be helpful for taking timely measures to prevent contamination of the groundwater quality of the areas near the dumping site.

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