Impact Assessment of Solid Waste on Groundwater and Soil in and around of Dumping Site, Kasba Bawada, Kolhapur

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Abstract. This research paper includes a 6 months environmental study of impact assessment of solid waste on Groundwater and Soil in and around of dumping site at Kasba Bawada, Kolhapur that includes a detailed study of the groundwater and soil characteristics. The dumping and open burning practices will led to the percolation of waste into the soil and groundwater which will eventually lead to various health and environment issues. In order to assess the groundwater and soil quality, assessment was carried out for the Groundwater and Soil near the dumping and landfill site around the 1 km radius in ecosystem is indeed an important resource which has yet to be studied on a bigger scale to meet the ever increasing demand for the water and soil for their use as resources. 6 Groundwater and 5 Soil sampling sites are selected in and around the dumping site. During the project, various physical, organic, inorganic and nutrient parameters were studied and also the detection of the heavy metals was carried out for soil and groundwater analysis. Most of the groundwater parameters are within the limit of BIS and WHO standards of drinking water except Total Solids which is higher in all sites and Nitrate which are higher than the limits in 2 sites when compared with the standards as these sites are near and around the dumping sites. The Nutrient parameters of Soil like Organic Carbon, Organic Matter, Available Phosphorous are present higher than the limit in all the sampling sites. The presence of high organic Carbon and the Organic matter with Available Phosphorous indicates the good fertility of the soil in and around the dumping site. The heavy metals are within the limit in soil when compared with the standards whereas in the groundwater, Lead, Copper, Nickel and Cadmium are present higher than the limit when compared drinking water quality standards established by the BIS and the WHO standards during the post monsoon of 2019 and pre monsoon of 2020 for other parameters.

Index Terms: Groundwater, Heavy Metals, Soil, Solid Waste

I. INTRODUCTION

Kolhapur is city present in the western Maharashtra. It is present on the banks of the Panchganga River. It has population of 38.76 Lakhs as per the 2011 Census in Maharashtra. As per the 2011 census, more than 31 % of population lives in urban area. With the increase in the population and urbanisation their is increase in the waste production. There are two dumping sites in Kolhapur namely Line Bazaar near Kasba Bawada and Takala Dumping site which are operating from many years in Kolhapur.

According to the Municipal Solid Waste Rules 2016, “solid waste” is defined as solid or semi-solid household waste, sanitary waste, commercial waste, institutional waste, catering and market waste, and other non-residential wastes, street sweepings, silts removed from surface drains, horticulture waste, agriculture and dairy waste, and treated bio-medical waste excluding industrial waste. As per the MPCB reports, Maharashtra produces 23844.6 tonnes waste per day. Every day, more than 165 tonnes of trash are collected by the Kolhapur Municipal Corporation. With the passing of year these data will increase and lead to various consequences.

In Maharashtra, as per the MPCB Reports there are more than 500 local bodies of Kolhapur City that are represented as metro cities, corporation, “A” class councils,“B & C” class councils, Cantonments Board and Nagar Panchayat which increases per year. There is a trend following in the increase in the councils that are represented in the Table 1[24].

There has been a rise in the generation of garbage over time. According to Annual reports of MPCB, every year there has been an increase in garbage generation as well as an increase in waste treatment as per the reports of MPCB, in Maharashtra from 2015 to 2019. During the study, it was discovered that trash generation had increased marginally for cities like Kolhapur, Amaravati, Navi Mumbai, Aurangabad, Chandrapur, Nagpur and Thane whereas there is higher generation of waste for Mumbai and Raigad when compared with other cities. Nashik, Kalyan and Pune has double the generation of waste from 2016 to 2019 when compared with 2015-16 data.

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Table 1 – Increasing trends in the Kolhapur Councils

Kolhapur	Corporations	"A" Class Councils	"B" Class Councils	"C" Class Councils	Cantonments	Nagar Panchayats	Total
2008-09	355	60	79	55	-	-	549
2010-11	355	60	79	55	-	-	549
2014-15	355	100	65	91	10		621

The study from the MPCB Annual reports about the treatment of the MSW at various cities from 2015 to 2019 for the cities like Kolhapur , Nagpur, Navi Mumbai, Raigad and Thane shows increasing trend for treating the waste every year. Aurangabad, Chandrapur, Kalyan and Nashik shows that MSW treatment was less in 2016-17 year when observed with 2015-16 report which later on for the year 2017-18 and 2018-19 was increased. For, Amaravati, the data was not available for 2017-18 while the treatment was two times high for the year 2018-19 when compared with 2015-16 data. While Pune and Mumbai shows very good trend for treating the waste when compared with other cities.

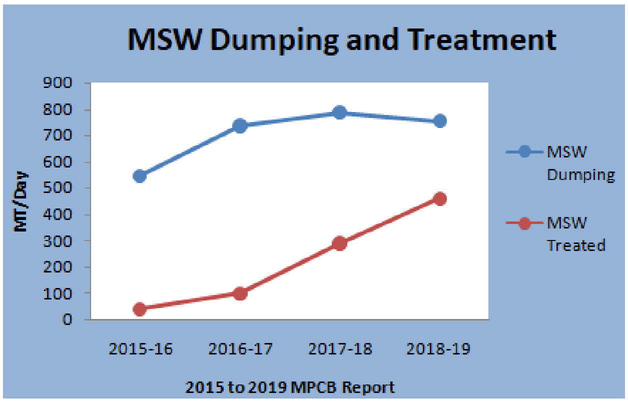

Figure 1. Waste Generation and Treatment in Kolhapur during 2015-19

The Fig.1, represents the generation and treatment of the MSW of Kolhapur city which shows the trend for the year2015 to 2019 [24]. From 2015 to 2018, there was an upward trend in the generation of waste. The data for 2018-19 shows less waste generation when compared with data of 2017-18. While for the treatment there is an increasing trend for the treatment of the waste per year from 2015 to 2019. According to the MPCB Reports from 2015 to 2019, there are variation in the collection of the waste and the treatment. During the year 2015-16, only 8 % of waste was treated and remaining 92% was untreated where as in 2016-17, 14% was treated and 86% was untreated. In the year 2017-18, 37% was treated that lefts 63% of waste as untreated whereas in the year 2018-19, 61% was treated and 39% was left as untreated.

Groundwater reports are prepared by three recognised governmental bodies in Maharashtra namely: MPCB (Maharashtra Pollution Control Board), CGWB (Central Ground Water Board), and GSDA (Ground Water and Survey Development Agency). MPCB check the groundwater twice a year as during April and October. As per the Report from MPCB, there were few parameters that were analysed in order to see whether the groundwater sample meet to the standards or not. The parameters like pH, D.O, Sulphates, Nitrates, Sulphates and Total Hardness, TDS, fluoride and microbial content were analyzed. There were variation in the sampling site numbers as station code that ranges from 14 to 16 per year in the report of the Kolhapur City, in which these parameters were analysed and based on the (WQI) Water Quality Index, they determine the quality of the groundwater.

Table 2- MPCB Data of WQI for Groundwater Sampling Stations of Kolhapur

Station Code		219	220	2004	2005	2006	2007	2008	2202	2829	2830	2831	2832	2833	2834	2835	1992
2015-16	Apr	42	33	208	329	228	582	222	28	26	206	157	52	644	660	33	37
	Oct	27	29	65	249	55	64	139	29	72	218	72	41	29	30	30	
2016-17	Apr	27	33	158	152	135	128	132	25	56	135	140	38	24	497	28	
	Oct	62	19	182	112	157	145	191	23	198	101	117	20	35	36	19	
2017-18	Apr	25	23	14	79	72	24	215	7	64	84		38	37	189	32	
	Oct	8	21	151	127	44	151	211	22	67	17	119	24	35	37	24	
2018-19	Apr			262	207	64	484	231	54	282	91	180	46	323	351	40	
	Oct			186	96	44	75	120	28	70	110	171	28	36	50	46	

Table 3- Groundwater Classification Based on the WQI

WQI Value	Water Quality	Colour Code
<50	**Excellent**	
50-100	**Good Water**	
100-200	**Poor Water**	
200-300	**Very Poor Water**	
>300	**Water unsuitable for drinking**	
	Not Collected	
	No Data	

The data includes a 4 year of study from different sampling location by MPCB. Variation is observed during the study that is represented in Table 2 [24] whereas the Table 3 [24] represents the WQI Index that helps in determining the quality of the water and the colour code representing the quality of the water. The data that determines of the quality of the groundwater is prepared on the basis of WQI which is calculated by the MPCB.

Pollutants are transferred from the waste material to the percolating water through a mix of physical, chemical, and microbiological processes in the waste, resulting in a highly polluted leachate by Christensen Thomas [1,2,3] and same was concluded by Durmusoglu Ertan [4]. Improper management could lead to the poor hygiene, spreading of various disease and pollution of air, soil and water resources. The usage of contaminated groundwater, which has been contaminated by leachate, is the most widely cited threat to human health from these landfills studied by Rajkumar Nagarajan [5]. The exposure to the diseases during the mishandling of waste when various unwanted chemical reaction takes place because of the mixing of the various chemical and hazardous waste during the dumping, open burning and percolation**.**

The open burning practices leads to the release of various harmful toxic gases that when evaporated leads to various respiratory diseases. Over the period of time, the various animal like cow, buffalo, pigs and stray dogs , rodents like rats, snakes and insects like mosquito and flies are attracted to these sites which become a hub for various diseases like the malaria by mosquito.

II. STUDY AREA

2.1 Description of Study Area

Kolhapur city is known as Karveer Nagari. The city is located at latitude 16.41’28.70”N and longitude 74.14”41.51”E having average rainfall of 1025 cm and elevation 546 m above sea level. The Study was carried out at Dumping Site, Line Bazaar near Kasba Bawada of Kolhapur City during a period from October to February in the year 2018-19. The plant works under the Zoom Bio-fertilizer Company Pvt Ltd in 4 acres of land for compost from solid waste.

The Kolhapur Municipal Corporation is looking for the processing of the solid waste into fertilizer as their main product for fertilizer production. The fertilizer project is carried out in 16.76 hectares of land at Halsavade.

2.2 Transportation of waste

The Kolhapur city being divided into 11 wards and the waste is collected through various sources like wards, govt and private hospitals, streets. Trucks, Ghanta gaadi, Tipper and Dumpers are used to collect the waste. The project runs under the RAMKEY Groups. The waste are dumped at the Kasba Bawada where it is further treated by the Zoom Biofertilizer Pvt Ltd where the biodegradable waste are used to make fertilizer and the non-biodegradable waste are then processed to the landfill sites.

2.3 Site Selection and Sampling

In Kolhapur there are 2 dumping sites as one is near the KMC (Kolhapur Municipal Corporation) Sewerage Treatment Plant, near Kasaba Bawda and other at the Sanitary Landfill Site near the Takala Park, Kolhapur.

The sampling was carried out at Dumping Site of Kasba Bawada, Kolhapur within 1 km distance during a period of 6 months from October 2018 to February 2019 which carries the sampling studies from monsoon, post-monsoon and pre-monsoon. There are 6 Groundwater sites which are coded as ‘GW’ from GW-1 to GW-6 samples and 5 soil sites which are coded as ‘S’ from S-1 to S-5 samples that are selected for sampling . In order to evaluate the influence of MSW on soil and groundwater, locations were chosen from within a one-kilometer radius of the dumping site.

The locations are selected in such a way that it will help us to know the pollution level around the MSW Dumping site.

III. MATERIAL AND METHODOLOGY

The Groundwater sample was collected in 1 litre of Plastic bottles that was washed at the time of sampling. The water from Hand pump and Bore well is allowed to run for 1-2 minute and then collected in the sampling bottle. The Groundwater parameters like pH and Electrical Conductivity (EC) were checked in the digital pH meter and Conductivity meter. The inorganic parameters like Acidity and Alkalinity were determined by acid base titration method, Hardness by complexometric method, Chloride by Argentometric method and Open reflux method was used to determine Chemical Oxygen Demand (COD). Gravimetric methods were used to determine Total Dissolved Solids (TDS) and Total Solids (TS). Nutrients parameters like Sulphate, Phosphate and Nitrate were carried out by Turbidometric method, Ammonium Molybdate method and UV spectrophotometric method. Heavy metals for groundwater were checked on the Atomic Absorption Spectrophotometer (AAS) by using Analytic Jena novAA 300 instrument. The water parameters were carried out by following the Standard methods for the examination of water and wastewater from APHA (American Public Health Association) [23] and BIS (Bureau of Indian Standards) Manual [28].

At a depth of 15-30 cm, a soil was dig by spade and was taken with the help of the hand trowel. The sample was collected in the plastic bags with the field data sheets. The sample collected was then brought in the lab and was air dried and divided into four portions. The portion diagonal to each other was collected further in the bag and was crushed, sieved and used for the analysis. The soil sample was mixed with distilled water and prepared in the 1:2 ratios for Soil parameters like pH and Electrical Conductivity (EC) which were checked in the pH meter and Conductivity meter (Jackson, 1973). Nutrient parameters like Available Nitrogen were carried out by Alkaline Potassium Permanganate method, Available Potassium by Flame Photometer method and Available Phosphorous by Olsen method. Organic Carbon by Walkley and Black method and Organic Matter was obtained by multiplying the Organic Carbon with 1.724 (factor). The Atomic Absorption Spectrophotometer was used to check for heavy metals in soil samples. The heavy metals were checked using an Analytic Jena novAA 300 equipment. The Soil parameters were carried out by following the "A Textbook of Soil Analysis" by H.P.Barthakur and T. Baruah [22] and "Soil Management Practical Manual" of Indira Gandhi Krishi Vishwavidyalaya[25].

During the sampling field data sheets were used to the write the sample type as Groundwater and Soil with location. It was also mentioned with the date and timing of the sample collection. It also includes field remarks as observation studies which help in the interpretation of the data.

IV. STATISTICAL ANALYSIS AND SOFTWARE

For Graph plotting mean calculation method is used for different parameters which represent the respective sample code for groundwater and soil as in Fig 4 and 8 Column Graph is used from MS-Excel. For Fig. 1, 6 and 9, Line Graph is used from MS-Excel whereas for Fig. 5 and 7, Originlab Software is used. For data calculation MS-Excel is used. For plotting sampling site location on the map, Google Earth is used represented in Fig 2 and 3.

Figure 2. Groundwater location near dumping sites

Figure 3. Soil locations near dumping site

V. RESULT AND DISCUSSION

Table 5 -Karl Pearson Correlation for Groundwater Parameters

	pH	EC	Acidity	Alkalinity	Hardness	Chloride	COD	TS	TDS	TSS	Sulphate	Nitrate	Phosphate
pH	1												
EC	0.45	1											
Acidity	0.05	0.52	1										
Alkalinity	0.69	0.77	0.21	1									
Hardness	0.54	0.58	-0.06	0.54	1								
Chloride	0.67	0.67	0.17	0.61	0.81	1							
COD	0.72	0.34	-0.21	0.71	0.48	0.42	1						
TS	0.43	0.86	0.57	0.63	0.47	0.62	0.18	1					
TDS	0.23	0.79	0.62	0.50	0.41	0.42	0.11	0.77	1				
TSS	0.43	0.50	0.24	0.44	0.28	0.50	0.20	0.70	0.11	1			
Sulphate	0.64	0.61	0.12	0.56	0.80	0.96	0.34	0.57	0.47	0.36	1		
Nitrate	0.52	0.25	-0.13	0.35	0.74	0.36	0.58	0.11	0.19	0.003	0.34	1	
Phosphate	0.54	0.49	0.17	0.56	0.24	0.68	0.25	0.53	0.27	0.51	0.65	-0.27	1

Table 6 -Karl Pearson Correlation for Soil parameters

	pH	EC	Available N	Available P	Available K	Organic Carbon	Organic Matter
pH	1						
EC	0.79	1					
Available N	0.87	0.91	1				
Available P	0.63	0.55	0.35	1			
Available K	0.81	0.63	0.56	0.94	1		
Organic Carbon	-0.16	-0.5	-0.13	-0.48	-0.27	1	
Organic Matter	-0.17	-0.51	-0.14	-0.47	-0.26	1	1

The Karl Pearson Correlation was studied in comparison with the groundwater parameters where the Chloride shows a highly positive correlation with Sulphate. Electrical Conductivity (EC) has a positive relationship with Total Solids (TS) and a marginally optimistic relationship with Alkalinity, Total Solids (TS), and Total Dissolved Solids (TDS). Hardness shows a marginal optimistic positive correlation with Chloride and Sulphates. Similarly, Total Solids (TS) also shows a marginal positive correlation with Total Dissolved Solids (TDS) which is represented in Table 5, respectively.

The Karl Pearson Correlation was also studied in comparison with the Soil parameters where a highly positive correlation was observed in the Organic Carbon and Organic Matter. In Nutrient parameter like Available Phosphorous and Available Potassium a highly positive correlation was also observed. A Positive relation was also observed in the Electrical Conductivity (EC) and Available Nitrogen. An Optimum Positive relation was also observed in the pH and EC, Available Nitrogen and Available Potassium represented in Table 6, respectively.

The various physicochemical parameters were analyzed for groundwater during the 6 months of period. In Groundwater samples, the pH ranges from 7.28 to 8.12, which is within BIS[27] and WHO[32] standards. The water samples are neutral to alkaline in nature. The same values as 7.3-8.3 were observed by K K. Deshmukh [6] in groundwater near dumping site of Sangamner City. The sample GW-1 is having higher pH when compared with other samples as the site GW-1 is near to the dumping site. There are anion and cations present in the water samples that leads to the electric charge indicated as the Electrical Conductivity (EC). EC ranged from 537 to 1360 us/cm which is higher in GW-1when compared with other sites. The EC averagely ranged from 441-1335 us/cm in peizometer groundwater at municipal solid waste landfill site by Grzegorz Przydatek [7]. The Acidity in water has as a quantitative reaction with strong base leading to the neutral charge which ranges from 20 to 38 mg/l.

The Alkalinity ranges from 115 to 249 mg/l which is within the acceptable limit but higher than permissible limit of BIS standards. It is higher in the GW-1, may be due to the leaching of waste and percolation due to the rain and also because of the use of the sprinklers done after open burning to let off the fire. It is slightly high in GW-6 as it near the agricultural farm where may be the use of pesticides or fertilizers that have percolated in the groundwater is the reason the for the alkalinity in water when compared to desirable limit. The Alkalinity range is higher in GW-1 and GW-6 samples except when compared with other samples and are within the acceptable limit of BIS standards. Unnisa S.A [8] found alkalinity values ranging from 40 mg/L to 260 mg/L in groundwater at a Jawahar nagar open dumping site (2017). Because groundwater is used for residential purposes, hardness is an important physicochemical characteristic observed by Adelekan B.A [9].The presence of Calcium and Magnesium Bicarbonate in water sample results in temporary hardness while Calcium and Magnesium Chlorides results in permanent hardness. The hardness ranges from 140 to 280 mg/l which is high in GW-1, GW-3 and GW-6 samples when compared with the BIS standards and are within the limit as per the WHO standards. The GW-3 and GW-6 are near to the agricultural sites, the use of pesticides, fertilizers and agricultural runoff may have percolated in the groundwater which has resulted in the increase in the hardness level in these sites while GW-1 is near the dumping site. Total hardness is high as it ranged from 150 to 3750 mg/l by Alam A [10] at an open dumping site at Mehmood Booti Lahore, Pakistan. The chlorides are present naturally in the water bodies because of the presence of the salts. The chlorides are within the limit when compared with the BIS [27] and WHO [32] standards. Sachin Mishra [11] noticed the same, with chloride levels ranging from 39 to 205 (mg/L) in the pre-monsoon and 35.50 to 144 (mg/L) in the post-monsoon, all of which were below the WHO guideline and BIS acceptable limit.

The Chemical Oxygen Demand (COD) is the test that helps to know the oxygen demand to degrade organic and inorganic matter. The COD is found to be high in the GW-1 when compared with other sites. The presence of oxidizable organic compounds that had leached from domestic garbage at the landfill site is indicated by the high COD value in the groundwater. Senthamil Selvan Kuppusamy [12] found that COD concentrations ranged from 26 to 168 mg/l in the summer and 27 to 134 mg/l in the winter. Total Solids (TS) is calculated by adding TDS (Total Dissolved Solids) and TSS (Total Suspended Solids). The TS is having the overall the dissolved salts and fine suspended particulate matter in the water bodies that ranges from 950 to 2100 mg/l is found to be higher than acceptable limit but within permissible in all samples when compared with BIS standards. The TSS are the fine suspended particulate matter that are present naturally in the water that ranges 350 to 1100mg/l which is lowest in GW-4 and highest in GW-6. During a study by Rishi Rana [13], the TSS levels of groundwater were found to be 236-1200 mg/l . The TDS in water bodies is due to the presence of the inorganic salts and organic matter which range from 500 to 1400 mg/l which is within the limit when compared with BIS [27] and WHO[32] standards respectively while TDS concentration was found to be 1000-3000 during the Investigation of physicochemical characteristics and heavy metal distribution profile in groundwater system around the open dump site by Kanmani S. [14]

The Nutrient parameters like Sulphates, Nitrate and Phosphate were also analyzed. When compared to WHO [32] standards, the Sulphate levels ranged from 78.16 to 235 mg/l, which is high in GW-1 and GW-3 but within the BIS acceptable limit. The presence of the sulphates in the groundwater is due to the leaching of the waste in GW-1 and in the GW-3 as may be because of the agricultural runoff and a open sewage drainage passing near by the sampling point. Sulphate concentration varied from 78 to 321 mg/l and 86 to 353 mg/l for May and December months respectively by Senthamil Selvan Kuppusamy [12]. Phosphate is naturally present in groundwater as a result of the weathering of rocks and the erosion of soils that mix with the groundwater. It varies between 0.16 and 0.81 mg/l during the studies. The concentration of phosphate ranges from 0.23 to 1.04 mg/L in groundwater at the solid waste dumping site near Ghazipur, Delhi observed by Kamboj N [15]. The Nitrate ranges from 15.53 to 57.64 mg/l which is higher in sample GW-1 and GW-3 as the site GW-1 is near to the dumping site where their could be percolation of the different kinds of waste during open burning of unwanted organic and inorganic waste into the groundwater and the site GW-3 is near the agricultural farm where the use of chemical fertilizer or pesticide have percolated in the water as it was observed, the use of both by the farmers for farming during the sampling time and an open sewage drainage passing near by sampling site. Nitrate was found to be higher than the limit set by WHO and BIS [27] for GW-1 and GW-3 site. It may be due to the domestic sewage, or agriculture runoff near to the sampling location observed by Sachin Mishra [11] as Nitrate value was observed to be from 16 to 142.6 (mg/l). The average concentration of various parameters of groundwater samples are represented in Fig 4.

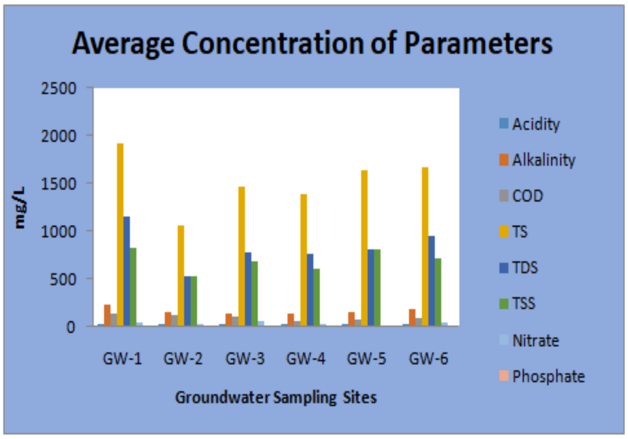

Figure 4. Average Concentration of Physicochemical Parameters in Groundwater sampling sites

Monthly Variation in the Hardness, Chlorides and Sulphates are represented in the Fig 5. During the study it was observed that during October sampling Hardness was higher at GW-4, Chloride and Sulphates in GW-1 while in December, Hardness and Sulphates was found high in GW-3 whereas Chloride was high in GW-1 when compared with other sampling sites. The study in February revealed that Hardness, Chloride and Sulphates was found to be higher in GW-1 only irrespective of other sampling sites. The groundwater sampling site near the MSW dumping site is having high Hardness, Chlorides and Sulphates indicating that the concentration of these parameters are high at the centre of the dumping site. The concentration goes on decreasing from the centre of the MSW Dumping site towards the other sampling sites.

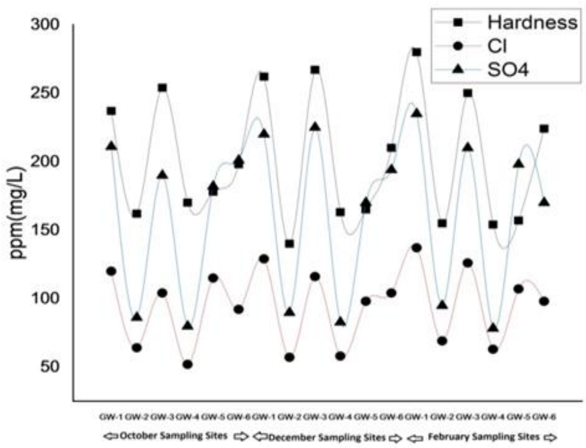

Figure 5. Hardness, Chloride and Sulphate in Groundwater represented month wise

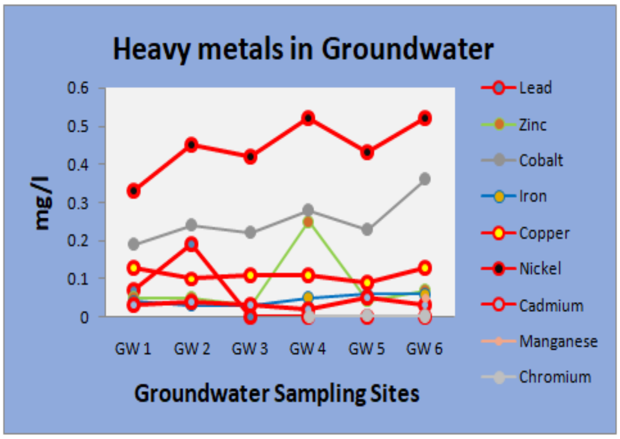

Figure 6. Average concentration of Heavy metals in Groundwater sampling sites

Heavy metals are defined as the metallic chemical element that is having a high density and is toxic if found in high concentration. Though, the elements have vital role in day to day life and they are not toxic unless and until their concentration gets increase. Only if their concentration gets increase then only they are called as toxic. In order to check their concentration as they are normal or toxic, various standards are available at nation, state and international state wise. Heavy metals, such as iron, lead, zinc, manganese, copper, nickel, cadmium, cobalt, and chromium, were also tested in order to determine the presence of metal toxicity in the water. The Lead is found to be higher than acceptable limit of BIS [27] standard in GW-1, within limit in GW-2 and Below Detectable Limit (BDL) in other samples. Inflow and outflow water included lead concentrations ranging from 0.001 to 0.094 mg/l and 0.001 to 0.150 mg/l, respectively, which did not exceed Polish and WHO (2011) drinking water regulations by Izabela A. Talalaj [16]. But also lead was found higher than the WHO standards in groundwater at Oti landfill site by Boateng T.K [17]. The Zinc, and Iron is within limit respectively when compared with the standards. The Cobalt is present in all the samples and their range is from 0.17 to 0.43 mg/l. (comparison could not be made with the standard as there is no standard limit for cobalt).

Copper was found in all of the samples and varied from 0.17 to 0.50 mg/l, which is greater than the BIS [27] standards' allowed limit. The mean concentration of the copper in the analyzed groundwater samples was 0.2 mg/L which seems to be above the desirable value by Kanmani S [14]. All the groundwater samples contained nickel, ranging from 0.20 to 0.57 mg/l, which is more than the BIS standards. Akhilesh Jinwal [18] observed the nickel higher than the BIS limits at 2 sites ranging as 0.03 and 0.032 mg/l. The Cadmium is present in all the samples and they are ranged from 0.01 to 0.07 mg/l which is higher than the BIS standard. Boateng T.K [17] also found the samples to be in the range that is higher than the allowed limit. The Manganese is found present only in GW-6 which is within the limit and Below Detectable Limit (BDL) for all other samples when compared with BIS standards. The Chromium is present higher in GW-5,within limit in GW-6 and BDL in other samples when compared with BIS standards. The Fig 6. shows the average concentration of heavy metals in the groundwater sample where GW-2 higher in lead, GW-4 higher in zinc and nickel, GW-5 higher in iron and cadmium, and GW-6 higher in cobalt, iron, copper, manganese, and chromium. The Lead, Copper, Cadmium and Nickel are higher than the standards in the groundwater samples and thus are represented by red line.

Principal Component Analysis - PCA (Principal Component Analysis) is a graphical representation for determining the relationship between distinct sampling sites and parameters**.** According to Principal Component Analysis, PC 1 has a total variability of 49.50 % while PC 2 has a total variability of 23.54 % represented in Fig.10. All metrics in GW-4 and GW-5 have a negative correlation at PC 1 and PC 2, with the exception of acidity, which has a positive correlation. PC 1 has a negative association with GW-3, but PC 2 has a positive correlation. At the 2nd Quadrant, GW-2, GW-3, and GW-6 exhibit a negative correlation at PC 1 and a positive correlation at PC 2. At 3rd Quadrant, GW-1 and GW-3 shows highly positive correlation at PC 1 and PC 2.

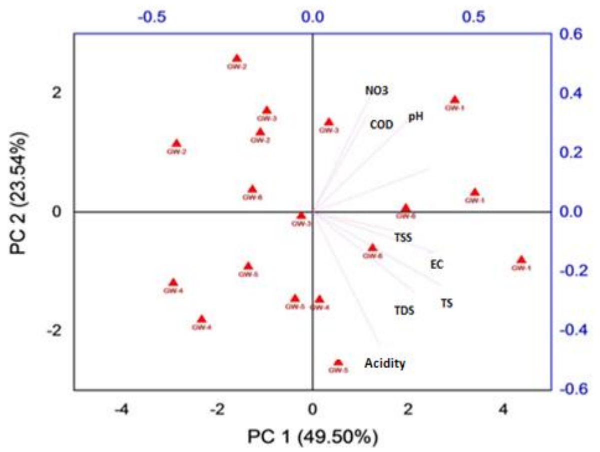

Figure 7. PCA correlation Biplot of various physicochemical parameters of groundwater sampling sites. Symbol represents score on PC 1 (x-axis) and Physicochemical Parameters for Groundwater on PC 2 (y-axis)

At 4th quadrant, GW-1, GW-4, and GW-6 display a negative correlation at PC 2 and a positive correlation at PC 1 respectively in Fig. 10. pH, COD, Alkalinity, and Nitrate have a significant positive relationship at PC 1 and PC 2, whereas TSS, EC, TS, TDS and Acidity have a positive relationship at PC 1 and a negative relationship at PC 2. The deposition of various kind of waste and leaching into groundwater had led to show positive relation for pH and Alkalinity at GW-1 same for the COD and Nitrate at GW-3 because of agricultural runoff as it is near to an agricultural land was observed in the 3rd Quadrant in Fig.10 .GW-6 shows positive correlation for the TSS, TS, TDS and EC due to the leaching of the agricultural runoff as observed in the 4th quadrant in Fig 7.

The pH ranges from 6.45 to 10.27 indicating that soil is moderately acidic to strongly alkaline. The pH is found to be higher in S-5 sample may be because of the leaching of the waste and and mainly the deposition of ash on the top soil. pH ranges from 8-8.7 in the soil near the solid waste dumping site in Tepi town, southwest Ethiopia because of the high metallic burden of different kind of waste by Besufeked Mekonnen [19]. Electrical Conductivity (EC) ranges 0.17 to 0.52 mS/cm which seems to be higher at S-5 sample because of leaching of waste. EC ranges from 1.8 to 4.92 mS/cm in soil at dumping site by Besufeked Mekonnen [19] due to the variation in the composition of the waste. The samples are also analyzed for nutrient parameters like Organic Carbon, Organic Matter and Available NPK contents where the Organic Carbon ranges from 3.6 to 7.4 % and Organic Matter ranges from 5.6 to 12.72 % which was found to be higher in all soil samples when compared with standards and was higher in samples S-2 followed by S-1 and S-5. The sample S-2 is having higher organic carbon and organic matter because it is near to agricultural farm where may be the deposition of dead dried leaves, twig, agricultural waste and cow dung that may have added the nutrients in the soil. The Organic carbon ranged from 0.88 to 2.10 % in soil by Alex Amerh Agbeshie [20]. The samples for pH, EC and Organic Carbon are compared with the standards provided in the Soil Testing in India, Dept. of Agri. and Cooperation, Ministry of Agriculture, Govt. of India, 2011[26].

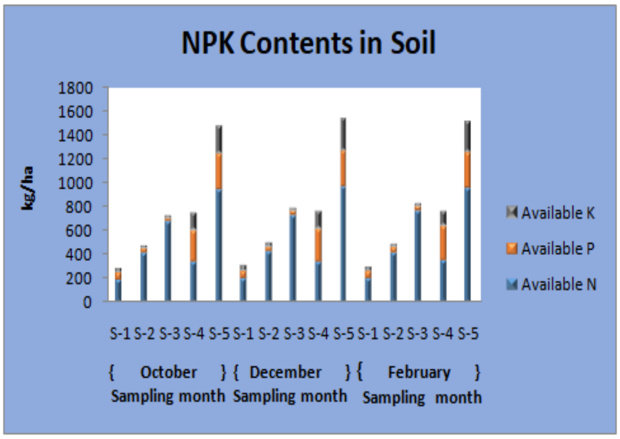

Figure 8. NPK in Soil represented month wise

The NPK level of the soil is critical for soil fertility and plant growth. The Available Nitrogen ranges from 188.25 to 958.63 kg/ha and was found to be higher in the sample S-5 (958.63 kg/ha) followed by S-3 (763.82 kg/ha) when compared with the standards as they are near the dumping sites. Keshav K Deshmukh [21] also observed nitrogen nutrient quality in the soil near dumping site which ranges from 88 to 282 kg/ha. The other important nutrient like Available Potassium ranges from 21 to 271 kg/ha and was found to be higher in S-5(272 kg/ha) followed by S-4 (154 kg/ha) when compared with all other samples. The Potassium is higher than the limits in these two sites as they are near the dumping sites. Soil fertility in soil of potassium ranges as 75 to 260 kg/ha by Keshav K Deshmukh [21]. The Available Phosphorous was found to be higher in all the soil samples when compared with the standard and they ranges from 28 to 308 kg/ha. The phosphorous was found to be high in the sample S-5 (301 kg/ha) followed the S-4 (289 kg/ha) as they may be leached with the waste because of open burning waste over the period of time. The amount of phosphorus in the soil may increase as a result of the transportation of leachate from the MSW dumping yard, since it ranges from 15.3 to 78 kg/ha in soil, according to Keshav K Deshmukh [21]. The soil samples for NPK contents are compared with the standards provided in the Soil Testing in India, Dept. of Agri. and Cooperation, Ministry of Agriculture, Govt. of India, 2011 [26]. The average concentration of nutrient parameters in the soil samples like Available Nitrogen, Available Potassium and Available Phosphorous was found to be higher in S5 when compared with other samples is represented in Fig 8, respectively.

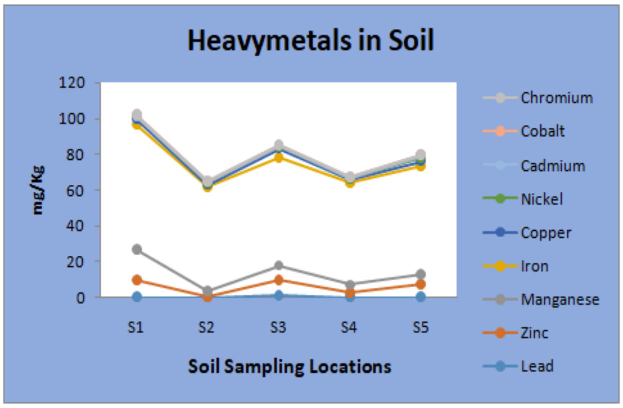

Figure 9. Average concentration of Heavy metals in Soil

The soil samples were also tested for nine different heavy metals like Iron (Fe), Lead (Pb), Zinc (Zn), Manganese (Mn), Copper (Cu), Nickel (Ni), Cadmium (Cd), Cobalt (Co) and Chromium (Cr). The concentrations of the heavy metals in soil samples were found to be within permissible levels when compared with the screening and response levels by MoEF&CC, GoI [31]. The average concentration of heavy metals in soil sample were represented in Fig 9, respectively. During the study S-1 is higher in zinc, cobalt, iron and manganese, GW-2 in chromium, GW-3 in lead & copper and GW-5 in cadmium and nickel were observed. The average concentration of heavy metals in different soil locations are represented in Fig 9.

VI. CONCLUSION

The groundwater and soil sample during a study of 6 months from October to February shows that there is contamination of the groundwater. The groundwater is affected by the dumping and open burning activities. The groundwater sample collected from the sampling sites is not suitable for drinking purposes. The sample collected near the dumping site is highly polluted so it has to be treated before daily use while samples from other sources can be used for washing, bathing purposes only but not for drinking and so for them minor treatment is required as there are presence of few heavy metals which are exceeding the limits. The recharging of the groundwater can further decrease the pollution load. The soil sample collected from the study area is having good amount of nutrients. The heavy metals are within limit in soil. Proper segregation of waste, disposal, proper management and control, and different types of treatments depending upon the type of waste should be carried out to prevent the pollution of soil and groundwater. The study also suggests to monitor the quality of soil and groundwater to study further the effect of open burning and dumping practices.

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