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Physico-Chemical Analysis of Subsurface Water in the Vicinity of Municipal Solid Waste Dumping Sites of Satna District, India

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Abstract: *Water percolates through the solid waste and generates leachate. Leachate generated from municipal solid waste dumping sites affects the groundwater quality in the adjacent areas through percolation in the subsoil. The usual and the most neglected cause of water pollution are uncontrolled dumping of municipal solid waste. Leaching of this leachate and heavy metals into the soil leads to the contamination of both soil and groundwater. Infiltration of water by rainfall, water already present in the waste, or water generated by biodegradation, cause the leachate to leave the dumping ground laterally or vertically and find its way into the groundwater thereby causing contamination. Subsurface water samples collected during the rainy season of 2013, 2014 and 2015 from the study area/region and the samples were analyzed for various physical and chemical properties. During the study it was found that Total Dissolved Solids varies from 646 mg/L to 886 mg/L and compared with permissible limits. The concentration of calcium and magnesium in all water samples is very high. Therefore, the best accepted option is to avoid the possibility of polluting the groundwater resources.*

Keywords*: Municipal solid waste, Subsurface water, Leachate, Contamination, Physical and Chemical Properties.*

I. Introduction:

Municipal Solid Waste (MSW) is complex refuse consisting of various materials with different properties. Some of the components are stable while others degrade as a result of biological and chemical processes. Generation of solid waste continues to increase in urban India with rapid urbanization, rising incomes, changing consumption patterns and a shift from recycling to a throw-away society. In urban areas the problem of solid waste management is very acute due to dense development and congestion. Solid waste management is an obligatory function of urban local bodies in India. Most urban local bodies are unable to cope with the challenging task of collection, transportation and disposal of solid wastes not only due to rapid urbanization and rising incomes but also due to the non-availability of required open-spaces near urban centers for land filling. Waste, therefore, often accumulates in open spaces, wasteland, streets, and even stagnant water bodies causing serious health and environmental problems. Leachate resulting from this is hazardous pollutant to the soil and ground water underlying. Leaching of this leachate and heavy metals into the soil leads to the contamination of both soil and groundwater.

While solid waste management generally consumes a significant proportion of municipal budgets, revenues from the service are negligible. The urban local bodies are also often under-staffed and lack adequate number of vehicles to transport waste. Disposal of waste is becoming an even more serious problem in solid waste management with land availability within accessible distance becoming scarce mainly due to rapid growth of cities and towns. Management of municipal solid waste is a service, which needs efficiency improvements and also substantial financial support in order to bring about significant change in the service. Waste management systems have not been able to keep pace with the huge volumes of organic and non-biodegradable wastes generated daily. As a consequence, garbage in most parts of India is unscientifically disposed and ultimately leads to increase in the pollutant load of surface and groundwater courses. In most parts of the country, waste water from domestic sources is hardly treated, due to inadequate sanitation facilities. This waste water, containing highly organic pollutant load, finds its way into surface and groundwater courses, very often close to dense pockets of human habitation from where further water is drawn for use [2-5].

Groundwater is that portion of subsurface water which occupies the part of the ground that is fully saturated and flows into a storage area under pressure greater than atmospheric pressure. Groundwater occurs in geological formations known as aquifer. [6] Landfills are considered as one of the major threats to the groundwater [7-8]. The scale of this threat depends on the concentration and toxicity of contaminants in leachate, type and permeability of geologic strata, depth of water table and the direction of groundwater flow [9]. Water through rainfall is mixed with the water already present in the solid waste piles which causes the leachate to leave the dumping ground as infiltration in lateral or vertical directions to find its way into the ground water thereby causing the contamination [10-11]. Municipal landfill leachate is highly concentrated complex effluent which contains dissolved organic matters; inorganic compounds such as ammonium, calcium, magnesium, sodium, potassium, iron, sulphates, chlorides and heavy metals such as cadmium, chromium, copper, lead, zinc, nickel; and xenobiotic organic substances [12-13].

It is therefore necessary to check the quality of ground water at regular time intervals to study the danger of its possible contamination which may cause water-borne diseases to human population. The determination of physical & chemical parameters of water samples which also dictate various other life processes should be taken as an environmentally viable study [14-15].

The present study involves the analysis of water quality in terms of various parameters of subsurface water in and around the different municipal solid waste dumping sites of Satna district, M.P. The aim of the study is to understand how the water gets polluted due to the dumping of municipal solid waste in and around the selected study areas.

II. Material and Methods

2.1 Description of the Study Area:

The ten major towns of Satna district were selected for the study of subsurface water quality in the vicinity of municipal solid waste dumping sites of Satna district. These dumping sites are from Satna (Adarsh Nagar, hawai patti), Maihar (near hospital), Unchehara, Nagod, Birsinghpur (near temple), Majhaganwa, Kothi, Chitrakoot, Amarpatan, Ramnagar as shown in figure 1.

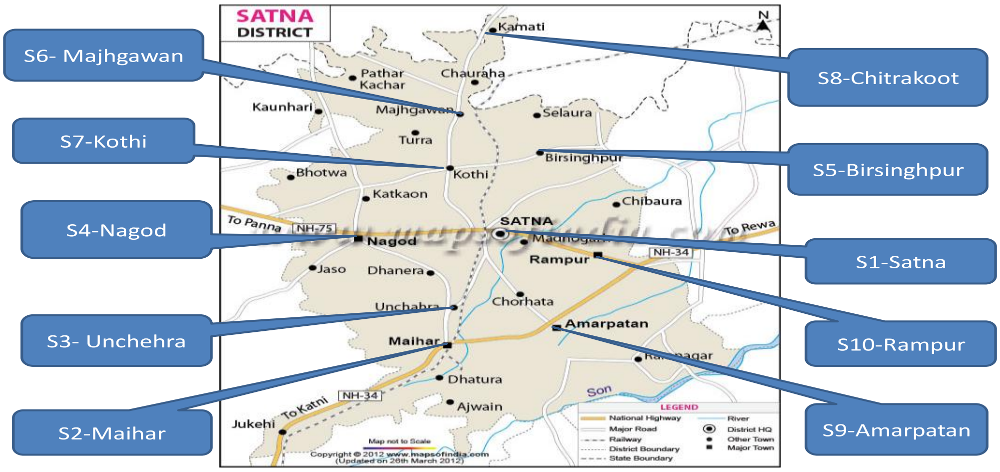

Figure-1 Subsurface water sampling locations, in the vicinity of municipal solid waste dumping sites of Satna district

2.2 Field Sampling and Laboratory Analysis:

Survey was conducted during the months of August, September, October (rainy season) of year 2013, 2014 and 2015 of the ten different municipal solid waste dumping sites all around Satna District. All the samples were collected from near the municipal solid waste dumping sites, sampling locations consisting of bore wells and hand pumps were selected in the study area. Sampling was done in accordance with grab sampling methods in 1litre plastic containers and prior to collection all the bottles were washed with non-ionic detergent and rinsed with de-ionized water prior to usage. Before the final water sampling was done, the bottles were rinsed three times with well water at the point of collection. During sampling from hand pumps and bore wells, the water pumped to waste for about five minutes and sample was collected directly. Each bottle was labeled according to sampling location while all the samples were preserved at 4ºC and transported to the laboratory.

2.3 Physico-Chemical Analysis:

All the samples were analyzed for the following parameters: Temperature, pH, Electrical Conductivity (EC), Turbidity, Total Dissolved Solid (TDS), Total Alkalinity (TA), Total Hardness (TH), Chloride, Calcium hardness, Magnesium hardness, Dissolved Oxygen (DO), Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Fluoride, Nitrate, Nitrite, Sulphate. The physicochemical analysis of water samples were carried out in accordance to standard analytical methods (APHA). pH determination was carried out by digital pH meter (HACK make), turbidity by using Nephelometric turbidity meter. The heavy metals were analyzed by using Atomic Absorption Spectrophotometer (Varian make).

III. Result and Discussion

In present study the subsurface water samples were collected in the vicinity of ten different municipal solid waste dump sites of Satna district. The physico-chemical characteristics of subsurface water sample of Satna district of ten different municipal solid waste dump sites are presented in Table-1.

Table-1 Physico-Chemical Parameters of the subsurface water samples near the municipal solid waste dumping sites of Satna district.

S. No.	Parameters	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
1	Temperature (^{0}C)	28.9	28.5	29.2	27.8	25.5	27.8	25.5	24.5	28.1	28.4
2	pH	6.82	7.92	7.89	6.70	7.85	7.54	6.67	6.73	7.80	7.35
3	Turbidity (NTU)	2.9	1.5	1.5	2.0	1.7	1.5	2.0	1.9	2.8	2.5
4	Electrical Cond. (μS/cm))	822	714	845	802	671	812	794	819	802	703
5	TDS (mg/l)	886	780	837	880	646	774	756	807	751	769
6	TSS (mg/l)	72	46	54	35	40	59	45	67	56	45
7	Total Solids (mg/l)	958	826	891	915	686	833	801	874	807	814
8	Total Alkalinity (mg/l)	170	159	153	140	148	156	145	167	138	164
9	Total Hardness (mg/l)	398	386	359	365	359	320	345	312	332	329
10	Calcium Hardness (mg/l)	256	258	247	248	267	232	243	214	228	227
11	Magnesium Hardness (mg/l)	142	128	112	117	92	88	102	98	104	102
12	Dissolved Oxygen (mg/l)	4.6	5.1	4.2	5.0	4.3	4.2	5.2	5.2	6.4	5.7
13	COD (mg/l)	8.8	9.3	8.0	6.3	8.4	7.6	5.8	6.3	8.0	6.3
14	BOD (mg/l)	3.5	3.1	3.3	2.8	3.2	3.0	3.2	3.4	3.0	2.8
15	Chlorides (mg/l)	55	76	85	33	76	79	53	67	70	47
16	Fluorides (mg/l)	0.70	0.40	0.50	0.90	0.70	0.60	0.50	0.30	0.10	0.40
17	Nitrate (mg/l)	3.50	4.12	1.78	4.65	0.10	0.01	0.60	0.35	3.45	5.80
18	Nitrite (mg/l)	1.25	0.20	5.25	5.22	3.67	5.50	0.30	2.20	5.10	0.30
19	Sulphate (mg/l)	3.33	3.45	2.40	0.68	3.17	3.80	2.79	1.21	1.08	4.59
20	Iron as Fe (mg/l)	0.55	0.21	0.42	0.30	0.39	0.35	0.31	0.20	0.03	0.38
21	Lead as Pb (mg/l)	0.70	0.50	0.67	0.65	0.56	0.55	0.80	0.68	0.61	0.60
22	Zink as Zn (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

*S - Subsurface water samples from bore well / hand pump, ND - Not Detectable

Sampling Locations: S1- Satna (Adarsh Nagar,hawai patti), S2- Maihar (near hospital), S3- Unchehra, S4- Nagod, S5- Birsinghpur (near Temple), S6- Majhgawan, S7- Kothi, S8- Chitrakoot (MP), S9- Amarpatan, S10- Rampur

Temperature: The temperature of bore-well water samples varies from 24.5^{0}C to 29.2^0 C.

pH: The pH of all the water samples was about neutral, the range being 6.54 to 7.92.

Turbidity: Turbidity of all the water samples ranges from 1.5 to 2.9 NTU, the values are under the limits of BIS.

Electrical Conductivity (EC): The EC of all the water samples varies from 671μS/cm to 845μS/cm. It is a valuable indicator of the amount of material dissolved in the water. The high value of EC can be related to the effect of the leachate seepage towards the bore-wells. According to Langenger (1990), the importance of the electrical conductivity is its measure of salinity, which greatly affects the taste and thus has a significant impact on portability of water.

Total Dissolved Solids (TDS): Total Dissolved Solids indicates the general nature of water quality or salinity. The range of TDS for water samples varies from 646 mg/l - 886 mg/l. The TDS concentration was found to be above the permissible limit may be due to the leaching of various pollutants into the ground water. The ground water pollution from refuge in the vicinity of the dumping sites is detectable through increased TDS concentration of water [19]. High concentration of TDS decreases the palatability and may cause gastro-intestinal irritation in human and may also have laxative effect particularly upon transits [24].

Total Alkalinity (TA): The concentration of Total Alkalinity as $CaCO_3$ in all the water samples ranges from 138 mg/l to 170 mg/l which are under the limits of BIS.

Total Suspended Solids (TSS): The range of TSS for the water samples varies from 35 mg/l to 72 mg/l. It may be due to the presence of several suspended particles. The total suspended solids are composed of carbonates, bicarbonates, chlorides, phosphates and nitrates of Ca, Mg, Na, K, Mn, organic matter, salt and other particles. The effect of presence of total suspended solids is the turbidity due to silt and organic matter. When the concentration of suspended solids is high it may be aesthetically unsatisfactory for bathing [28].

Total Hardness (TH): The total hardness of water samples varies from 312 mg/l to 398 mg/l, the desirable limit for hardness of water is 300 mg/l. The water in all sampling point is very hard.

Calcium Hardness: Calcium hardness in ground water samples ranged from 214 mg/l to 267 mg/l. The desirable limit for calcium is 75 mg/l, the concentration of calcium in all water samples is very high. Calcium often comes from carbonate based minerals, such as calcite and dolomite. The excess of calcium causes concretions in the body such as kidney and bladder stones and irritation in urinary passages.

Magnesium Hardness: Magnesium hardness in the bore-well water samples varies from 88 mg/l to 142 mg/l, the desirable for magnesium is 30 mg/l., the concentration of magnesium in all water samples is very high. Magnesium salts are cathartic and diuretic and high concentration may cause laxative effect, while deficiency may cause structural and functional changes. It is essential as an activator of many enzyme systems [24].

Dissolved Oxygen (DO): Dissolved Oxygen is one of the most important measures of water quality. It is found in the water samples ranges from 4.4 mg/l to 6.4 mg/l.

COD: The COD level in the water samples ranges from 5.8 mg/l to 9.3 mg/l, the COD is a measure of oxygen equivalent to the organic and non-organic matter content of water susceptible to the oxidation by a strong chemical oxidant and thus is an index of organic pollution [2].

BOD: The BOD level in the water samples range from 2.8 mg/l to 3.5 mg/l, the BOD is a measure of the amount of oxygen that microbes need to stabilize biologically oxidizable matter.

Chloride: The concentration of Chloride in the water samples ranged between 33 mg/l to 85 mg/l. which are under the limits of BIS. An excess of Chloride in water is usually taken as an index of pollution and considered as a tracer for ground water contamination [23].The Chloride content of ground water is likely to originate from pollution sources such as domestic effluents, fertilizers, septic tank and from the natural sources such as rainfall and the dissolution of fluid inclusion. Increase in chloride level is injurious to the people suffering from diseases of heart or kidney [24].

Fluoride: The concentration of Fluoride in the water samples ranged from 0.10 mg/l to 0.90 mg/l. Fluoride at low concentration in drinking water has been considered beneficial but high concentration may cause dental fluorosis (tooth mottling) and more seriously skeletal fluorosis [25].

Nitrate: The concentration of nitrate in water samples ranges from 0.01 mg/l to 5.80 mg/l, the values are under the limits of BIS.

Nitrite: The concentration of nitrite in water samples ranges from 0.20 mg/l to 5.50 mg/l.

Sulphate: The concentration of sulphate in water samples ranged from 0.68 mg/l to 4.59 mg/l, values are under the limits of BIS.

The water samples were analyzed for heavy metals such as Iron, Lead, Zinc, Nickel and Copper, which are characterized as undesirable metals in drinking water. The concentration of these metals was found to be below the BIS limit in ground water samples. This indicates that these metals are possibly absorbed by the soil strata or by the organic matter in soil.

IV. Conclusion:

From the present study of physico-chemical analysis of subsurface water in the vicinity of municipal solid waste dumping sites, it is found that some of the parameters like Total Dissolved Solid (TDS), Total Hardness (TH), Calcium and Magnesium concentration are above the limits of Indian Standard for drinking water (BIS- 10500:1991) and WHO. The higher concentration of TDS shows the penetration of landfill leachate has occurred to the subsurface water and polluted the water. While total hardness (TH) and Calcium and Magnesium hardness is due to the soil of that area because the place is renowned for Dolomite mines and Limestone. Hence we can conclude that at present the municipal solid waste has minimal impact on the subsurface water quality. Although the water quality is just good but it needs to be maintained from being polluted due to municipal solid waste dumping sites for the future. The emphasis should be given to improve the waste management practices and construct properly engineered landfill sites to curtail the ground water pollution.

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