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ASSESSMENT OF SURFACE WATER FITNESS FOR IRRIGATION USE NEAR BHUASUNI DUMPING SITE, BHUBANESWAR, ODISHA, INDIA

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ABSTRACT

The present study found that the mean concentrations of studied water quality parameter were below the permissible value as per BIS 2012 for drinking water except at two locations. The average ionic concentrations of cations and anions in the study area were in the order of Ca^{2+} > Na^{+}> Mg^{2+} > K^{+} and Cl^{-} > SO_4^{2-} >NO_3^{-} >F^{-} respectively. Water quality of the studied area does not upset the use of water in irrigation purpose except at two locations. The calculation of water quality indices like SAR, MAR, SSP, Na%, KR, Na:Ca, Mg:Ca indicate the fitness of water for agriculture.

KEY WORDS : Water Quality, Water Quality Indices, land fill leachate, Cations, Anions

INTRODUCTION

Surface dumping of municipal solid waste is the simplest, cheapest and most common waste management practice in most developing countries, with little attention paid to the impact on health and the environment (Longe and Balogun, 2010). But the poor management practices, especially in developing countries like India, are the main causes of environmental pollution by municipal solid wasten (MSW). Because the presence of toxic organic and inorganic constituents (ammonium, calcium, magnesium, heavy metals etc.) in MSW contaminate the water body through leachate (El-Gohary *et al.,* 2016). In many developing countries, unregulated landfills exist near major cities operate landfills without adequate leachate collection and treatment facilities (Singh *et al*., 2016). This generated landfill leachate affects not only the quality of surface and groundwater, but also organisms (Negi *et al.,* 2020). The magnitude of the effect depends on the nature of the leachate (Aderemi *et al*., 2011).

As the surface dumping of MSW is poorly carried out in India, there is a possibility of water pollution due to leachate (Sharma *et al*., 2018), the same can be observed in Bhubaneswar, a smart city (Mohanty *et al.,* 2014). Currently, the city Bhubaneswar produces more than 400 tons of MSW per day. The city's population growth and the per capita production of MSW are putting great pressure on city authorities to dispose this amount of waste. To manage this amount of MSW, the Bhubaneswar Municipal Corporation (BMC) has allocated 61,485 acres of land in Bhuasuni village by the government of Odisha in 2008 for solid waste disposal purposes. Due to surface and groundwater resources pollution by landfill leachate and its irresistible environmental importance, to this end, the current study of surface water quality assessment has been done arround the Bhuasuni dumping site.

Study Area

Bhubaneswar is between 85 ° 44 'E to 85 ° 55' E longitude and 20 ° 12 'N to 20 ° 25' N latitude in the Khordha district of Odisha (JNNURM, 2013) where the MSW dumpyard of the BBSR is geographically located at 20^0 23' 30.28"N and 85^0 47' 18.20"E at Bhuasuni village and is covering an area of 61.485 Acres (Fig 1). Some villages near the landfill are

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Bhuasuni, Daruthenga, Tulasadeipur, Jujhagada, Krushnanagar, Sunderpada, Chandaka, etc. The site is drained by small streams that flow into Jhumuka Nala. The drainage pattern of the study areaare distributed by three different order patterns and are interconnected by nallas and the the nallas in turn empty into the Mahanadi River.

METHODOLOGY

Surface water samples were collected from ten locations (Table 1, Figure 1) near the bhuasuni landfill site in polyethylene bottles for analysis of fourteen physico-chemical characteristics: pH, electrical conductivity (EC), total dissolved solids (TDS), dissolved oxygen. (DO), biochemical oxygen demand (BOD), total hardness (TH), calcium (Ca^{2+}), magnesium (Mg^{2+}), nitrate (NO_3-), sulfate (SO_4^{2-}), chloride (Cl^-), sodium (Na^+), potassium (K^+), Fluoride (F^-), according to standard methods provided by the American Public Health Association, Washington, DC (APHA 2005). Parameters such as dissolved oxygen (DO) and pH were analyzed at the time of sampling. For water quality assessment, its suitability for irrigation purposes and source of pollution finding, different pollution indices tool (Table 2) were used.

RESULTS AND DISCUSSION

Physico-chemical parameters study for drinking purpose suitability

The obtained fifteen parameter data presented in Table 1 were usedto obtain various information by comparing with prescribed desirable and permissible limits of the Bureau of Indian Standards (BIS 1998, 2012). Also for the assessment of best designated use of surface waterquality criteria as per CPCB (2007). The indicator parameter pH determines the suitability of water for various purposes. The mean pH values of all sampling stations ranged from 6.58 to 8.41. Conductivity (EC) is an indirect measure of total molten salt. Generally, the ideal value of EC for all irrigation waters is less than 750 µS/cm (Richards, 1954). Observed mean value for EC of study area was found to be ranging between 123ìS/cm at SW5 to 2115ìS/cm at SW9. Highest value was observed at location SW9 and was expected due to leachate input from dumping site. As per Richard 1954, 70% of the samples EC value (< 250; Low salinity hazards) fall in low saline class and were useful for every kind of crops and every types of soil. Whereas 10% of the samples falls in the moderate saline zone class (250-750) and only can be used for normal salt tolerant plant. Rest 20% of water sample falls in high saline zone (750-2250) and is not suitable for irrigation for plant. On the other hand totaldissolved solids (TDS) values recorded were (80% sample) underthe desirable limits of 500 mg/l (BIS, 2012). The observed highest value was of 1155mg/l at SW9 and a lowest values of 68.8 mg/l at SW5. Higher levels of TDS in surface water at SW9 (1155mg/l) was the indicator of input of leachate activities along with surface agricultural run off. It was cleared from TDS index (Todd1980) that the TDS values for 90% of samples were below 1000 mg/l and thus water quality lies under freshwater class, indicating water can be used for irrigation purposes also. Total Hardness (TH) varies from 52 to 437mg/l through out the study area .The study reveals that the on the based of hardness category as per Sawyer and Mc. Cartly 1967 classification for TH values,20% of water samples lying in the soft, 60% water sample lying in

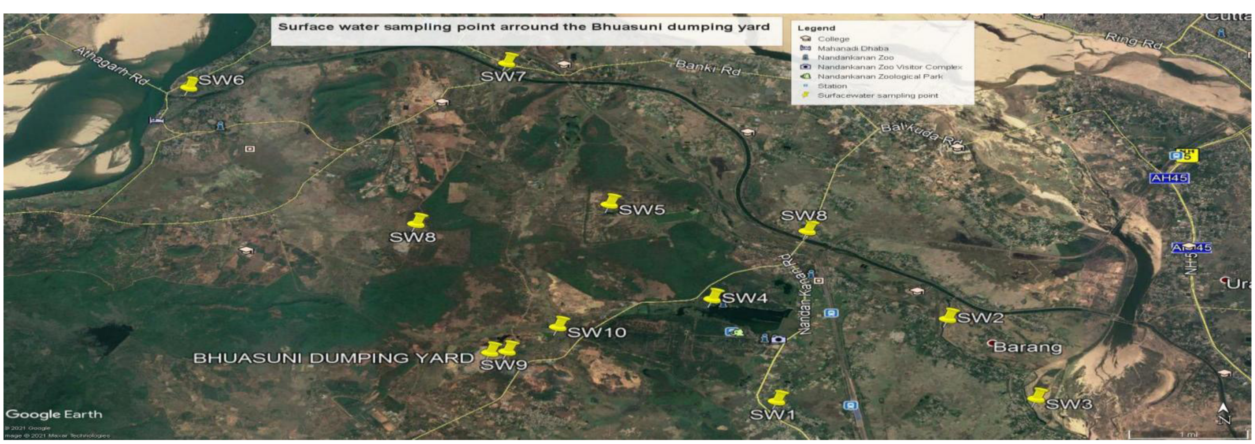

Fig. 1. Map of sampling points

Table 1. Analytical result of physico-chemical parameters and itscomparison with BIS standards for surface water samples

location	Sample code	pH	TDS	Cl^-	$SO4^{2-}$	TH	Ca^{2+}	Mg^{2+}	NO_3^-	D.O	B.O.D	F^-	Na^+	K^+	EC
Raghunathapur Pond	**SW1**	7.53	120.4	70	18.1	83	17.42	6.48	3.7	4.6	2.6	0.34	27.21	8	210
Near Baliapada	**SW2**	8.15	117.6	68	18.5	104	20.04	10.69	4.6	5	2.8	0.31	5.1	10	185
Gandarpur Kuakhai River	**SW3**	7.23	98.56	78	11.6	78	21.2	7.31	3.2	8	2.4	0.35	26.4	10	176
Nandankan Lake	**SW4**	7.3	302.4	99	12.7	136	29.06	13.6	4.7	4.4	3.2	0.25	30.2	10	540
Chudanga Pond	**SW5**	7.43	68.88	57	9.6	67	13.01	5.04	2.8	6.4	2	0.31	18.3	10.2	123
Mahanadi River from Munduli	**SW6**	8.41	128.8	54	11.4	100	23.23	11.13	3.3	7.2	2.4	0.25	4.8	3.2	230
Ramdaspur Godisahi Chhaka	**SW7**	6.58	121.2	66	15.4	52	25.44	4.56	2.1	5.6	2.8	0.26	15.3	5.4	215
Confluence point of Naraj Cuttack Puri Canal from Baranga	**SW8**	8.33	134.4	61	7.3	116	27.65	5.45	4.2	4.8	2.4	0.32	11	5	240
Adjacent to dumping yard	**SW9**	8.4	1155	231	38.1	437	52.15	33.31	18.1	2.7	13.3	0.61	50.1	35	2115
Near Ambabari	**SW10**	7.1	482.7	148	27	192	30.21	25.27	12.7	3.8	6.8	0.37	36.1	16.5	705
Standard BIS (*1998 and 2012)		6.5-8.5	500	250	200	200	75	30	45	*6	*3	1	200	12	1500unit
% of Sample Exceeding BIS limit		0	0	0	0	0	0	0	0	60	25	0	0	0	0

Note: Unit of all parameter are in mg/L except pH and EC (iS/cm)

moderately and 20% water sample lying in hard category.

Suitability study of water for irrigation

All the obtained ionic concentration of various chemical parameters of surface water sample analysis (Ca^{2+}, Mg^{2+}, Na^+, K^+) from ten location were converted to milliequivalent/litre (meq/l) and were used to calculate different water quality indices (SAR, SSP, KR, MAR, Na%, Na:Ca, Mg:Ca) by using equations given in Table 2 to find out the water suitability for irrigation purpose and the results are given in Table 3.

Irrigation water with excessive amount of saltsalters the soil structure, permeability, aeration and affect the plant growth Kundu and Nag, 2018) . Therefore forit is essential to have knowledge about the quality of water used for agricultural purpose

Sodium absorption ratio (SAR) is the most important quality criteria to check the water quality for agricultural uses (Kundu and Nag 2018). The equation 3 given by Richard (1954) is generally used to determine the SAR hazard index. Excessive levels of SAR can result in soil crusting, poor seedling appearance, poor aeration and root diseases, etc. (Rahman *et al*., 2017).The study reveals that the SAR values of studied area was ranging from 0.205 (at SW6) to 1.41(at SW1) as shown in Table 3. High SAR value (1.33) was also recorded at SW9 and was due to highest value (50.1mg/l) of observed Na^+ ion. The highest value of Na^+ at this point (SW9) may be due to leachate input from dumping yard. SAR value of water <10 belongs to excellent category (Richard 1954). It was evident from the study that 100% samples were the SAR values less than 10 marks and falls in excellent category.

Soluble sodium percentage is calculated by Todd (1980) equation (equation 4) given in Table 3. The exchange process of sodium in water for Ca^{2+} and Mg^{2+} in soil reduces the permeability and makes the soil with poor internal draining (Kundu and Nag, 2018). The SSP values in the studied area ranges between 9.143 (SW6) to 45.76 (SW1). The SSP clasification is as per Kundu and Nag (2018). The result shows that the calculated SSP value for 20% of sampleslies in excellent category (value of SSP<20); for 50 % of samples lies under good category (20<SSP<40) and rest 30% of samples lies under permissible category (40<SSP<60). This indicates the suitability of water for irrigation purpose.

Wilcox (1955) formula (equation 5) is used for calculation of sodium percentage. From Na% value study of water sample reveal that the quality of waterwere ranging from excellent to permissible category. Lowest and highest Na% values were calculated at location SW6 (12.29) and SW1(49.74) respectively (Table 3). The Na% clasification is as per Wilcox, 1955. It was found that 10%, 60%, 30% of water sample were lying under excellent (0<Na%<20), good (20<Na%<40) and permissible class (40<Na%<60). But overall the study was indicating the water is fit for irrigation purpose.

Raghunath (1987) formula (equation 6) is used to calculate magnesium adsorption ratio. Soil with higher magnesium concentrationcause defoliation over entire surface of leaf (Kundu and Nag, 2018). MAR values below 50 are fit for agricultural purpose, while more than 50 values have a negative impact on the soil and reduces the plant productivity (Raghunath, 1987). Callculated MAR values of water samples in Table 3 shows that the highest and lowest MAR value of 57.83, 22.71 were observed at SW10 and SW7 respectively. It was cleared that, 80% of collected water samples bearing MAR value below 50 mark and makes water suitable for irrigation but 20% of water sample (at SW9:51.15, SW10:57.83) posses MAR value more than 50 mark and lies in unsuitable for irrigation category.

Kelly (1963) formulates a mathematical statement for sodium in water known as Kelly's ratio (equation 7) and is given in Table 3. Kelley's formula reflects the balance among Na^+, Ca^{2+} and Mg^{2+} ions in water and predicted the fitness of water for agricultural uses. The water with a Kelly's ratio more than one is considered as unfit for irrigation while water with KR value below one is considered as fit for agricultural purpose (Kely, 1963; Kundu and Nag, 2018). It was found from the study that 100 % collected samples possess Kely ratio value well below range one and seems suitable for irrigation purposes. Higher values of KR at locations SW1 (0.844) and SW5 (0.748) were observed (Table 3). It was due to to observed high values of Na at these places

Mg:Ca and Na:Ca ratios determinethe suitability of water for agricultural purpose and if the Mg: Ca ratios values are below four then there is no risk of water infiltration problem in soil (Rahman *et al.*, 2017). But if it is greater than three then there is possible threat to the infiltration of agricultural water (Rahman *et al.*, 2017). Present study reveals that the mean value of Na:Ca ratio (0.0139) of all the location water is staying below three (Table 3). It indicates that there is no possibility of water percolation problem. The calculated value for Na:Ca

Table 2. Equations for diferent water quality indices

Indices	Equation	Indices	Equation
SAR	$SAR = \frac{Na^+}{\sqrt{\frac{Ca^{2+} + Mg^{2+}}{2}}}$ (eq. 3)	MAR	$MAR = \frac{Ca^{2+} \times 100}{Ca^{2+} + Mg^{2+}}$ (eq. 6)
SSP	$SSP = \frac{Na^+ \times 100}{Ca^{2+} + Mg^{2+} + Na^+}$ (eq. 4)	KR	$KR = Na^+ / (Ca^{2+} + Mg^{2+})$.. (eq. 7)
Na%	$Na\ \% = \frac{Na^+ + K^+}{Na^+ + K^+ + Ca^{2+} + Mg^{2+}} \times 100$ (eq. 5)		

Table 3. Calculated diferent water quality indices

Index	SW1	SW2	SW3	SW4	SW5	SW6	SW7	SW8	SW9	SW10
SAR	1.41	0.223	1.26	1.159	1.091	0.205	0.733	0.501	1.333	1.173
MAR	37.88	46.65	36.11	43.41	38.84	43.99	22.71	24.42	51.15	57.83
KR	0.844	0.118	0.692	0.511	0.748	0.101	0.404	0.261	0.408	0.44
SSP	45.76	10.56	40.89	33.83	42.794	9.143	28.784	20.726	28.98	30.47
Na%	49.7401156	20.269	45.83	37.93	49.833	12.29	32.80	24.89	36.54	35.733
Mg : Ca	0.609	0.874	0.565	0.767	0.635	0.785	0.294	0.323	1.05	1.371
Na : Ca	1.358	0.221	1.083	0.904	1.223	0.179	0.523	0.346	0.84	1.039
TH (Mg/l)	83	104	78	136	67	100	52	116	437	192
TDS (mg/l)	120.4	117.6	98.56	302.4	68.88	128.8	121.2	134.4	1155	482.7
WQI	52.3	55	47.5	63.8	45	45.5	42.3	52.1	155	84

ratio were ranging between 0.179 at SW6 to 1.358 SW1 (Table 3). A same kind of trend has seen in case of Mg:Ca ratio also. 100% samples were possessing Mg:Ca ratio < 4 and thus indicating suitability of water for irrigation purpose .

CONCLUSION

Results obtained in this study reveals the quality ofthe surface water has been impacted by the nearby municipal landfill site. The pollution indices like SAR, MAR, SSP, Na%, KR, Na:Ca, Mg:Ca were depicts the fitness of water for agriculture except the location adjacent to land fill site. In moving way from MSW dumping site, the index values decreases which indicates that land fill site might be the source of surface water pollution pollution near by dumping site .Therefore, with new policies such as (1) designing of separate collection and recycling of solid waste, (2) controlled landfill leachate collection and treatment systems (3) finally leachate formation would me minimized by properly covering the site.

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