Poll Res. 44 (3–4) : 270-275 (2025)

ISSN 0257–8050
DOI No.: http://doi.org/10.53550/PR.2025.v44i03-04.018
Journal Home Page: www.envirobiotechjournals.com

RESIDENTIAL GROUNDWATER QUALITY NEAR THE MUNICIPAL SOLID WASTE DUMPING FACILITY IN BHUASUNI (BHUBANESWAR), ODISHA, INDIA

AMARENDRA HARICHANDAN[1], KABIR MOHAN SETHY[2*], STHITAPRAGYAN PANIGRAHI[2] AND SMRUTIRANJAN PRADHAN[3]

[1]Hi-Tech Institute of Technology, Bhubaneswar, Odisha-752057, INDIA
[2]Department Geography, Utkal University, Vanivihar, Bhubaneswar 752 021, Odisha, India
[3]PNS School of Engineering & Technology, Kendrapada, Odisha, India

(Received 14 February, 2025; Accepted 23 April, 2025)

ABSTRACT

Except at location GW2, the mean concentrations of a few studied water quality parameters in all water samples were found to be below the permissible value for drinking water as defined by BIS 2012. The water samples from GW2 and GW1 have high values for water quality parameters (WQP) such as total dissolved solids (1111.7 mg/l), total hardness (311 mg/l), calcium (111 mg/l), nitrate (19.33 mg/l), and electrical conductivity (2016.67S/cm), which are all above the BIS 2012 drinking water standard. The water quality of samples collected from GW2 (76) and GW2 (57) is rated as very poor and poor, respectively. The water quality index (WQI) values in the area are GW2>GW1>GW4>GW9. A correlation study reveals that the following water quality parameters have the most significant influence on the WQI score: EC, F-, NO_3^-, TH, TDS, Ca^{2+}, Cl^-.

KEY WORDS: Water quality, Groundwater, Solid waste, Odisha state India

INTRODUCTION

Ingestion of water can expose humans to hazards by the compounds, generated by various human activities. Groundwater is the primary source of drinking water in India. Due to its suitability for a variety of functions in people's and society's daily lives, the quality of groundwater is as essential as its quantity (Schiavo *et al*., 2006; Shigut *et al*., 2017). The principal objective of the relevant authorities is to ensure that every individual has access to clean, safe drinking water for their health (Jamshidzadeh and Barzi, 2018). The quality of the world's water is a concern because of a rising trend of surface and groundwater contamination (Harichandan *et al.,* 2016; Harichandan *et al.,* 2017; Harichandan *et al.,* 2019; Harichandan *et al.,* 2021; Oyeleke and Okparaocha, 2016). In developing nations, uncontrolled landfills can be found adjacent to major cities (Panda *et al.,* 2014), emitting hazardous chemicals into bodies of water (Singh *et al.,* 2016). It has been determined that leachate from municipal solid waste landfills harms groundwater and surface waterways in urban areas (Naveen *et al.,* 2018). Leachate from the inappropriate surface disposal of municipal solid waste in India has the potential to contaminate water, as shown in the smart city of Bhubaneswar (Sharma *et al.,* 2018; Mohanty *et al.,* 2014; Harichandan *et al.,* 2022a; Harichandan *et al.,* 2022b). The city's municipal solid garbage is currently disposed of in the Bhuasuni region with little regard for the effects on human health and the environment. Groundwater is a crucial source of domestic fresh water in the region of the Bhuasuni dumpsite. Numerous researchers have emphasized the surface and groundwater pollution caused by landfill leachate and its significant major environmental impact, prompting the current examination of groundwater quality in the vicinity of the Bhuasuni landfill.

([2]Research Scholar, [2*]Professor and Head)

MATERIALS AND METHODOLOGIES

Study Area: The MSW dump yard of the BBSR is physically located at 200 23' 30.28"N and 850 47' 18.20"E in Bhuasuni village and covers an area of 61.485 Acres. Bhubaneswar is between 85 ° 44′E to 85 ° 55′E longitude and 20 ° 12′N to 20 ° 25′N latitude (Figure 1). Bhuasuni, Daruthenga, Tulasadeipur, Jujhagada, Krushnanagar, Sunderpada, Chandaka, etc., are a few villages close to the dump. Small streams that empty into Jhumuka Nala drain the area.

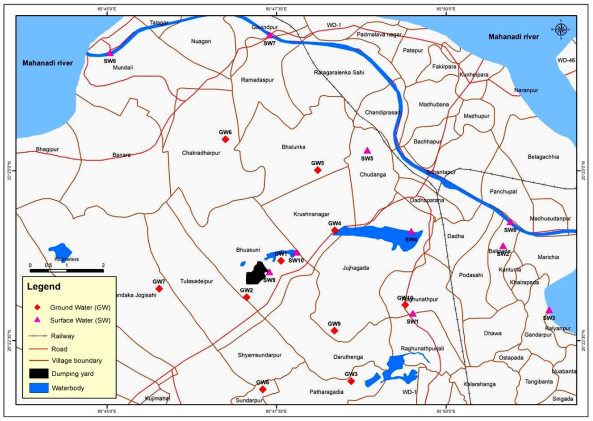

Fig. 1. Ten groundwater monitoring sites are marked on a location map near the Bhuasuni dump

Groundwater sampling and analysis: To establish a baseline for the area's groundwater quality, samples of water were taken during the summer, monsoon, and winter months from ten different bore wells near the Bhuasuni garbage dumping site (Figure 1 and Table 1). Ten groundwater monitoring sites within a 10-kilometer radius of the garbage were chosen. Water samples were obtained for Physico-chemical and heavy metal content analysis using the grab sampling method. The following parameters were measured for the assessment of twelve physicochemical properties: pH, electrical conductivity (EC), total dissolved solids (TDS), total hardness (TH), calcium (Ca^{2+}), magnesium (Mg^{2+}), nitrate (NO_3^-), sulfate (SO_4^{2-}), chloride (Cl^-), sodium (Na+), potassium (K+), and fluoride (F-). Samples were taken from these sampling points in sterile plastic bottles (APHA, 2005). With the aid of a pH/EC/TDS meter, parameters including pH, TDS, and EC were quickly assessed after the sample. The acquired Physico-chemical parameter data of groundwater from ten places were used to establish statistical analysis using Equation 2 and to assess the water quality class using WQI- Equation 1 (Bora and Goswami, 2017).

Table 1. Groundwater sampling location details and distance from the Bhuasuni dumping site.

S. No	Sampling station code	Sampling station	Distance from the dumping site (Meters)
1	GW1	Near Ambabari	417
2	GW2	Near Nuasahi	366
3	GW3	Near Nelachal Polytechnic	3578
4	GW4	Near jungle view hotel	2018
5	GW5	Near Krushna Nagar	3098
6	GW6	Near Chakradharpur	3461
7	GW7	Near Jogi Sahi	2337
8	GW8	Near Sunderpur	2927
9	GW9	Near ODM School Daruthenga	2306
10	GW10	Near Raghunathpur	3623

$$WQI = \sum q_n w_n / \sum w_n \quad \text{Equtaion - 1}$$

Where q_n = Quality rating of nth water quality parameter.

W_n = Unit weight of nth water quality parameter.

The quality rating (q_n) is calculated using the expression given in equation 'a'.

$$q_n = \left[\frac{V_n - V_{id}}{S_n - V_{id}}\right] \times 100 \quad \text{equation (a)}$$

Where,

V_n=Estimated value of nth water quality parameter at a given sample location.

V_{id} = Ideal value for the nth parameter in pure water (V_{id} for pH=7, for DO=14.6 mg/l and for all other parameters is zero)

S_n = Standard permissible value of nth water quality parameter.

The unit weight (W_n) is calculated using the formula given below.

$W_n = k/S_n$

Where,

S_n =Standard permissible value of nth water quality parameter.

k =Constant of proportionality, and it is calculated by using the bellow.

$$k = 1/\sum \frac{1}{S_n} = 1,2,3,\ldots\ldots,n$$

Also, utilizing the collected Physico-chemical parameter data, Karl Pearson Correlation matrix equation 2 (Kreyszig, 2004) was determined, where the closeness between the tested parameters and WQI was computed.

$$r = \frac{\sum_{i=1}^{n}(x_i-\bar{x})(y_i-\bar{y})}{\sqrt{\sum_{i=1}^{n}(x_i-\bar{x})^2}\sqrt{\sum_{i=1}^{n}(y_i-\bar{y})^2}} \quad \text{Equation 2}$$

RESULTS AND DISCUSSION

The results from obtained water quality parameters and pollution indices are explained based on water quality parameters, WQI, Correlation and regression studies of all twelve studied Physico-chemical parameters of ground are present in Table 2 depict that water samples from location GW2 possess values for different water quality parameter (WQP): TDS (1111.7 mg/l), TH (310.67 mg/l), Ca^{2+}(111.2 mg/l), NO_3^-(19.33 mg/l), EC (2016.67ìS/cm) are staying above the BIS 2012 drinking water standards. It indicates the water is unfit for domestic use at this location. Even same scenario has seen at location GW1 for parameter TDS :683 mg/l (>500mg/L) and NO_3^- : 15mg/L(>5 mg/l). The recorded values are staying above BIS 2012 &1998 standard (BIS 2012; BIS 1998). It was excepted as these locations are closure to dumping site. Except these locations, the recorded values of WQP from rest locations are staying well below the BIS 2012 standard.

The Water Quality Index, which reduces a large amount of data about water quality into a single number, is the most effective way to convey water quality (Adimalla *et al.*, 2018). The current study calculates the WQI using twelve significant water quality characteristics. In Table 3, these index values are compared to five different water class types to determine water quality. The estimated WQI values for several sampling sites range from 19 to 76 (Table 2, Figure 2). Because the WQI score is greater than 50, the water quality in the samples taken from GW2(76) and GW1(57) is classified as very poor and

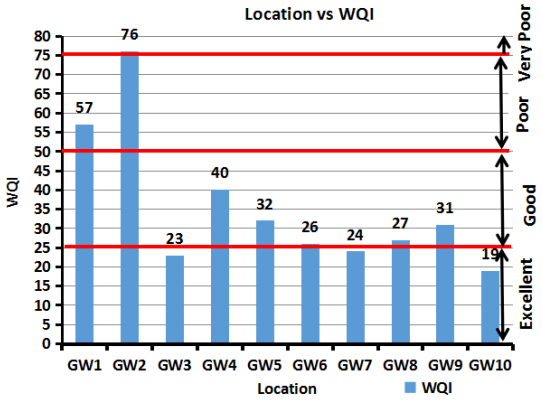

Fig. 2. Bar chart presentation for ten location and their WQI quality category

Table 2. Analytical result of twelve studied Physico-chemical parameters from ten groundwater location

Parameter	pH	TDS	Cl^-	SO_4^{2-}	TH	Ca^{2+}	Mg^{2+}	NO_3^-	F^-	Na^+	K^+	EC	WQI
Unit		mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	ìS/cm	-
GW1	7.5	683	54.3	47	186	68.7	13.9	15	0.61	28.9	5.7	1243.67	57
GW2	8	1111.7	83.2	63.6	310.67	111.2	27.2	19.33	0.76	35.8	10.1	2016.67	76
GW3	6.8	59.5	26.33	31.3	65	28.1	4.33	3.43	0.27	26.5	2.8	108.33	23
GW4	7.43	227.6	42	35	170	44.1	11	10.7	0.37	27.4	10.1	390.53	40
GW5	6.9	86	28	28	82.33	28.6	6.3	7.5	0.36	25.3	7.3	156.83	32
GW6	6.73	75	25	31	72	27.6	5.5	2.8	0.303	22.9	4.8	135.33	26
GW7	7.2	82.5	22	27	75.67	31.3	5.8	3.53	0.243	33.1	5.4	150.37	24
GW8	6.8	75.7	25.33	31	72	28	10	2.8	0.313	22.2	3.7	137.6	27
GW9	6.9	101	46.4	42.5	87.33	48.2	15.33	6.07	0.273	25.4	13.5	183.7	31
GW10	6.9	64.3	23.33	26	48	25	8	4.17	0.2	16.4	4.5	117	19
BIS 2012	6.5-8.5	500	250	200	200	75	30	5	1	200	12	1500	—

Table 3. The Water Quality Index is used to classify water types.

Index	Reference	Range value	Water type/ Classification	Probable use
WQI	Bora and Goswami 2017	0–25	Excellent	Drinking, irrigation and industrial
		26– 50	Good	Drinking, irrigation and industrial
		51-75	Poor	Irrigation and Industrial
		76-100	Very poor	Irrigation
		>100	Unfit for drinking	Proper treatment is Required before use

poor, respectively (Table 3). It was accepted because these two locations are near a landfill and leachate intrusion could cause declining water quality. However, the following locations had the lowest WQI: GW3, GW6, GW7, GW8, and GW10 (23, 26, 24, 27, and 19, respectively). It was to be expected, given how far these locations are from the disposal site and how good the water quality is. Location GW10 has the lowest WQI score of all the sampling points, with value of 19. While the WQI score for GW2 is the highest ever recorded (76). The WQI decreased almost, as one moved from a nearby to a distant location (GW2-76>GW1-57>GW4-40>GW9-31>GW10-19), indicating that water quality improved as one moved away from the dumping site.

The correlation study reveals a strong direct and indirect link between various water quality measures. According to the findings of a correlation study, the examined water quality parameter had a significant impact on several water quality indices at various sample points. Water quality parameters are important in determining a high WQI score: EC, F-, NO_3^-, TH, TDS, Ca^{2+}, Cl^-. WQI has a strong direct relationship with the studied parameters EC, F^-, NO_3^-, TH, TDS, Ca^{2+}, Cl^-, with correlation coefficients of r = 0.991, 0.985, 0.973, 0.969, 0.958, 0.945, respectively. There is a strong and direct relationship between EC-TDS (r = 0.991), Cl^--SO_4^{2-}(r = 0.984), Cl^--Ca^{2+}(r =0.984), SO_4^{2-}-Ca^{2+} (r =0.978), and TDS-F^-(r =0.970), as well as EC-F^-(r =0.969). It implies that mineral content in groundwater is due to water nutrient enrichment. The correlation also shows that soluble salts predominate in groundwater in the study area, with anthropogenic activities and rock containing CaCl2, MgCl2, CaCO3, and MgSO4 as

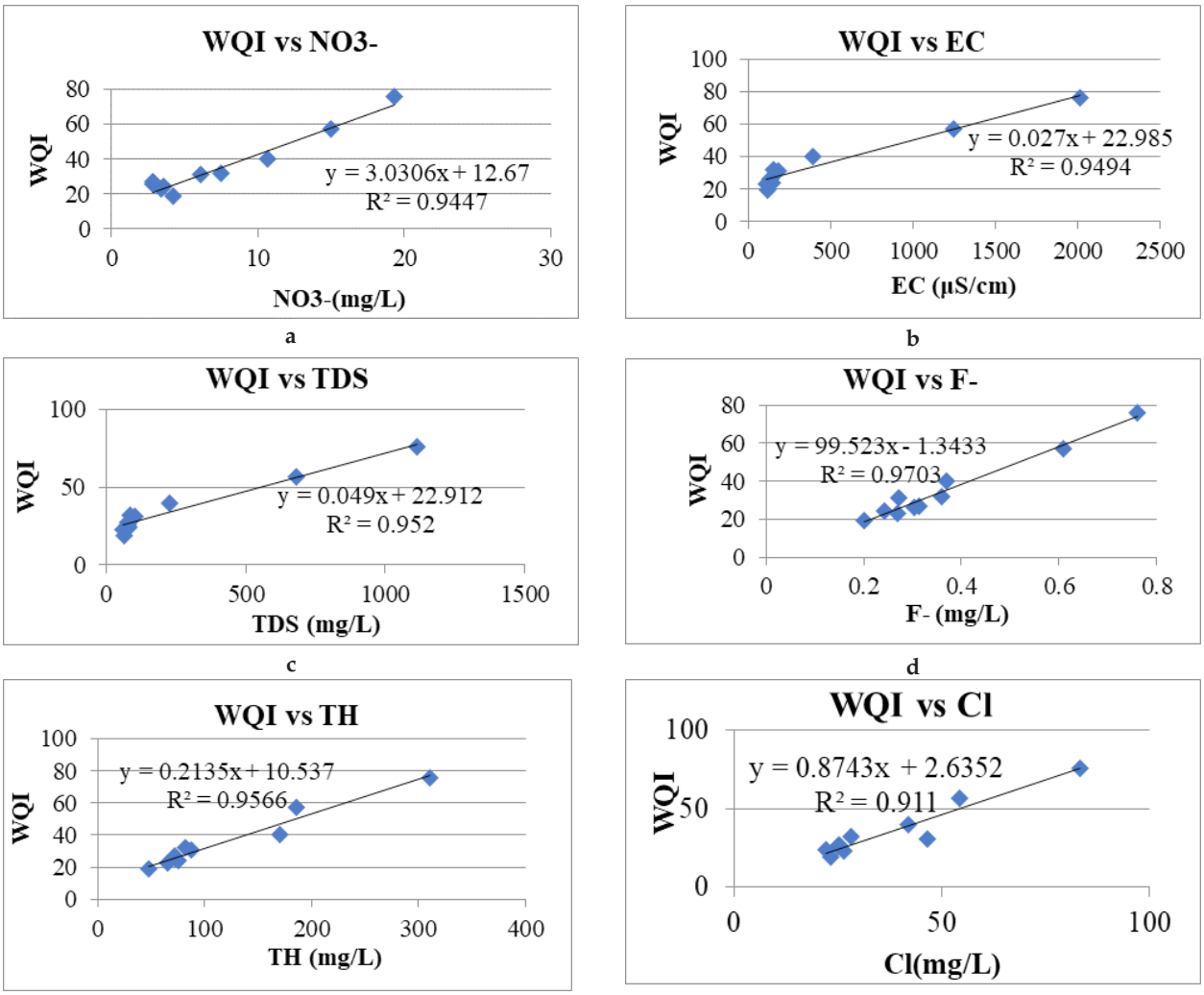

Figure 3A-3F. Regression study among WQI and studied ground water quality parameter

possible sources. At the same time, a significant positive correlation between Cl^--SO_4^{2-} (r =0.984), Cl^--Ca^{2+}(r =0.984), SO_4^{2-}-Ca^{2+} (r =0.978), and TDS-F^-(r =0.970) indicates that the possible sources of Cl^-, SO_4^{2-}, and F^- are same and from agricultural waste, landfill leachate infiltration into groundwater, and other anthropogenic activities.

Estimates from regression studies have greater significance when the R^2 value is close to one (Field, 2009)**.** This is what a regression analysis reveals. According to the research in (Figures 3A-3F), WQI has positively correlated with most of the physicochemical variables studied. Still, it is the water quality variables that have the most significant influence on WQI is F-. With R^2 values of 0.970, 0.956, 0.952, and 0.949, F^-, TH, TDS, and EC have the best regression toward WQI of all the studied Physico-chemical water quality parameters.

CONCLUSION

The results of the study demonstrate that several elements of water quality have an impact on the quality of groundwater near a municipal landfill. The observed values for a few parameters (TDS, TH, Ca^{2+}, NO_3^-, and EC) were only bouncing around the allowed limit, even though all readings were well below BIS 2012. The calculated WQI indicates that 50% of the water samples fall into the category of good-water quality, while each of 10% samples, fall into the categories of poor and extremely low water quality. The reduction in the WQI score shows that an adjacent solid waste dumping site may be the source of groundwater pollution. The WQI values for GW2 and GW1 indicate groundwater pollution by leachate. To prevent situations where heavy metals and other types of pollution exposure are present, new policies like (1) developing proper management of separate collection and recycling of solid waste, (2) controlling landfill collection and treatment systems, and (3) creating a new landfill site with an appropriate foundation would all help to delay the collection and transmission of leachate. Finally, by appropriately covering the site, leachate output would be decreased.

Conflict of Interest- **None**

REFERENCES

Adimalla, N., Li, P. and Venkatayogi, S. 2018. Hydrogeochemical evaluation of groundwater quality for drinking and irrigation purposes and integrated interpretation with water quality index studies. *Environ. Process.* 5: 363.

APHA. 2005. *Standard Methods for the Examination of Water and Waste Water*. 21st edn. American Public Health Association, New York.

Bora, M. and Goswami, D.C. 2017. Water quality assessment in terms of water quality index (WQI): case study of the Kolong River, Assam, India. *Appl. Water Sci.* 7: 3125-3135.

Bureau of Indian Standards (BIS). 1998. *Drinking Water Specifications (Revised 2003)*. IS:10500.

Bureau of Indian Standards (BIS). 2012. *Indian Standard Drinking Water Specification (Second Revision)*. BIS 10500:2012, New Delhi.

Field, A.P. 2009. *Discovering Statistics Using SPSS (and sex and drugs and rock 'n' roll)*. Sage Publications, Thousand Oaks, CA.

Harichandan, A., Patra, H. S. and Sethy, K. M. 2017. Evaluation of Water Quality of Local Streams at Gandhamardan Iron Mines, Suakati, Keonjhar District of Odisha, India. *J. Pollut. Eff. Cont.* 5:199. doi: 10.4176/2375-4397.1000199

Harichandan, A., Patra, H.S., Dash, A.K., Sethy, K.M., Sahu, S.K. and Ghosh, M. 2021. Suitability of groundwater quality for its drinking and agricultural use near Koira region of Odisha, India. *Sustain. Water Resour. Manag.* **7**, 51 (2021). https://doi.org/10.1007/s40899-021-00505-z.

Harichandan, A., Patra, H.S., Panda, R. and Sethy, K.M. 2018. Water Quality Assessment of Bhubaneswar Temple Pond by using Statistical Method and Water Quality Index. J. Pollut. Eff. Cont. 6: 231

Harichandan, A., Patra, H.S., Sethy, K.M., Mohanty, S.K. and Panda, R. 2016. Water quality index and correlation study of religious ponds in The Temple City, Bhubaneswar, Odisha. *Am J Sci Ind Res.* 7(2): 22-31. https://www.scihub.org/media/pdf/2016/05/AJSIR-7-2-22-31.pdf

Harichandan, A., Sethy, K.M. and Patra, H.S. 2022b. Assessment of surface water fitness for irrigation use near Bhuasuni dumping site, Bhubaneswar, Odisha, India. *Poll Res.* 41(2): 637-641. http://doi.org/10.53550/PR.2022.v41i02.035

Harichandan, A., Sethy, K.M., Routray, S.K. and Jogayya, K.N. 2022a. Study of surface water quality for domestic use near a municipal solid waste dumping site in Bhuasuni, Odisha, India. *Int. J. Energ. Water Res.* https://doi.org/10.1007/s42108-022-00205-0

Jamshidzadeh, Z. and Barzi, M. T. 2018. Groundwater quality assessment using the potability water quality index (PWQI): a case in the Kashan plain, Central Iran. *Environ. Earth Sci.* 77(3): 59.

Kreyszig, E. 2004. *Advanced Engineering Mathematics*. 8th ed. John Wiley & Sons (Asia) Pte. Ltd., Singapore. 1151 p.

Mohanty, C.R., Mishra, U. and Beuria, P. R. 2014.

Municipal solid waste management in Bhubaneswar, India – a review. *Int. J. Latest Trends Eng. Technol.* 3(3): 303–312.

Naveen, B.P., Sumalatha, J. and Malik, A.R.K. 2018. A study on contamination of ground and surface water bodies by leachate leakage from a landfill in Bangalore, India. *Int. J. Geo-Eng.* 9: 27.

Oyeleke, P.O. and Okparaocha, F.J. 2016. Assessment of some heavy metals in groundwater in the vicinity of an oil depot in Nigeria. *Am. Chem. Sci. J.* 12(3): 1–7.

Panda, P., Harichandan, A., Patra, H. S. and Parashar, K. 2014. Present practice of Municipality Solid Waste Management in Bhubaneswar, Odisha, India. *Int. J. Energy Sustain. Environ. Eng.* 1(1): 28–34.

Schiavo, M.A., Havser, S., Gusimano, G. and Gatto, L. 2006. Geochemical characterization of groundwater and sub-marine discharge in the southeastern Sicily. *Continental Shelf Res.* 26(7): 826–834.

Sharma, A., Gupta, A.K. and Ganguly, R. 2018. Impact of open dumping of municipal solid waste on soil properties in mountainous region. *J. Rock Mech. Geotech. Eng.* 10(4): 725–739.

Shigut, D.A., Liknew, G., Irge, D.D. and Ahmad, T. 2017. Assessment of physico-chemical quality of borehole and spring water sources supplied to Robe Town, Oromia region, Ethiopia. *Appl. Water Sci.* 7(1): 155–164.

Singh, S., Raju, N.J., Gossel, W. and Wycisk, P. 2016. Assessment of pollution potential of leachate from the municipal solid waste disposal site and its impact on groundwater quality, Varanasi environs, India. *Arab. J. Geosci.* 9(2): 1-12.