World Applied Sciences Journal 37 (2): 121-126, 2019
ISSN 1818-4952

DOI: 10.5829/idosi.wasj.2019.121.126

Evaluation of Potential Physico-Chemical Ground Water Pollution: a Case Study of Kiwanja Market, Kenya

[1]*Agnes W. Macharia,* [2]*Wesley K. Kirui and* [1]*Isaiah Omosa*

[1]Kenyatta University, School of Engineering and Technology,
Civil Engineering Department, P.O. Box: 43844-00100, Nairobi, Kenya
[2]Kenyatta University, School of Engineering and Technology, Agricultural and
Biosystems Engineering Department, P.O. Box: 43844-00100, Nairobi, Kenya

Abstract: Ground water is a large source of water for utilisation in the world. This resource is not easily accessible to monitor its changes and its deterioration is not easy to reverse. In the current study, physico-chemical parameters for groundwater for Kiwanja Market (KM) were analysed and compared to the Kenya Bureau of Standards (KEBs) water quality. The pH, DO, temperature, turbidity, chlorine, iron, water hardness, potassium and calcium were analysed. All the parameters studied were within the stipulated levels except iron, chlorine and for samples from point C (Ebenezer Hostel). Turbidity for points A and C were above the permissible levels of KEBs standards. The water from point A and C may require further treatment to allow for domestic use. This analysis revealed to some extent a healthier system, though further analysis is needed to support this assertion. Continuous monitoring of the groundwater source within KM should be taken on regular basis to detect any changes and to sustainably maintain the quality of water within the required KEBs water quality standards.

Key words: Groundwater · Physico-Chemical · Metals · Solid Waste · Ground Water Pollution · Kebs Water Standards · Kiwanja

INTRODUCTION

Groundwater is the essential and largest source of water on earth for drinking, domestic and industry use as well as sustaining wetland ecosystems [1-5]. Ground water is the water found underground in cracks and soil pores, thus, it is hidden from view and not easily accessible [2]. This water resource is important since it is more balanced and many people depend on it for many activities. However, it is not accessible to many people in the recommended quality. Therefore, this source of water should be made safe and used sustainably. Conversely, in the current dispensation, when there is great competition for water resources, the sustainability concept at times is overlooked. The growing sub-urban areas in most developing countries are experiencing unprecedented challenges such as solid waste disposal related problems. The unplanned dumping of solid waste in the open areas close to the boreholes or shallow wells may lead to ground water contamination. This contamination results from runoff into the shallow wells or boreholes and the infiltrated water carrying with it dissolved contaminants or pollutants [3, 6]. These pollutants may originate from point and non-point sources courtesy of land use changes and anthropogenic activities [7, 8].

Infiltrates may percolate down through the soil layers, carrying with it dissolved pollutants to the aquifer contaminating groundwater [9, 10]. The dissolved pollutants get into the aquifer before they are naturally attenuated and water from these aquifers are collected and used. The users may suffer from contamination leading to health related problems and health costs. Contaminated groundwater use results in human health problems, which

Corresponding Author: Wesley K. Kirui, Kenyatta University, School of Engineering and Technology, Agricultural and Biosystems Engineering, Department, P.O. Box: 43844-00100, Nairobi, Kenya.

cause economic strain to the low-income earners, since in developing countries the cost of medication is prohibitively high. Recently there have been reports of cholera outbreaks in several urban areas of the country [11, 12]. This evidenced the deteriorated sanitation conditions in Kenya's urban centres.

The progressive deterioration of ground water quality due to anthropogenic activities is worrying. Therefore, regular monitoring is advisable, because once the groundwater is contaminated, it is extremely difficult to reclaim or restore back to its original condition [4, 13]. The potential pathways for the various contaminants are through the environment [3]. Organic and inorganic pollution affect groundwater negatively. Land use practices such as urban development, septic tanks, oil tanks and agricultural activities impact negatively on groundwater quality [14]. Poor solid waste management, storage, transfers and disposal of liquid waste contributes to the organic and inorganic pollution load to groundwater [15]. Poor solid waste disposal in Kiwanja Market a Peri-Urban fast developing area may have led to ground water pollution. This could result from seepage from dumpsite and deep percolation.

Groundwater can optimally and sustainably used only if its quantity and quality is assured. The assurance is obtained through assessment of various sampled groundwater from different locations within an area of interest and compared to the standards set by the authorities. Assessment of groundwater pollution will enable formulation of informed protection plan. Thus, assisting authorities in making informed management decisions and strategies, this is vital for sustainable development. In addition, to ensuring good quality water and predict the level of pollution before reaching unsafe levels. The objective of the current study was to assess the variation of physical and chemical properties of groundwater in Kiwanja Market because of ineffective solid waste disposal and compared with the Kenya Bureau of Standards (KEBS) [16] suggested permissible limits. KEBS water quality permission limits were derived from World Health Organisation (WHO) water quality standards [17].

MATERIALS AND METHODS

Study Location: Kiwanja Market is in Kahawa West ward, Roysambu constituency, Nairobi county Kenya. Piped water from Nairobi City Water and Sewerage Company is the main source of drinking water. Groundwater is the major supplementary source of water for various activities. There is no sewer line in the study area and majority of the residents utilize pit latrines for human waste disposal. In addition solid waste management system is not in place. Therefore, most of the solid wastes are disposed indiscriminately.

Data Sampling: To execute the work sampling water shallow wells were selected in such a manner to represent the entire study area. The guiding principles were the closeness to residential area. In general four sampling points were selected, these were (Generations hostel, Peniel flats, Ebenezer hostel and Future-leaders hostel) denoted A, B, C and D respectively. During sampling proper control was taken to ensure data quality is not compromised.

Sampling bottles were washed and rinsed using distilled water before sampling. In case of samples for metal analysis, polyethylene containers were rinsed with nitric acid and the samples were acidified to a pH of 2 before testing. Water from the sampling points was used to rinse the bottle twice before the sample collection. Each sample was clearly labelled and taken to the laboratory immediately for analysis. The transportation time did not exceed 2 hours. The samples for chemical analysis were preserved at 4°C. Analyses were carried out immediately upon arrival in the Laboratory. All sample and field notes were recorded in data books. Physical tests were carried out immediately after the sampling; the physical parameters tested were temperature, pH, Dissolved Oxygen (DO) and turbidity [17]. Samples for chemical testing were kept safe and transported to the laboratory for analysis. Established laboratory standard methods were used [18].

Turbidity measurements were carried out using portable turbidity meter (NTU AL250-IR). Hardness was evaluated using EDTA Titration method. Iron test was carried out using calorimetric method; Equipment used in the process was HI-3834 Iron Test kit. For sulphites, Sulphite test kit (HI-3822) Hanna Instruments were used which employs titration method.

Data Analysis: The data observed were analysed using excel sheet and presented. The integer mean values for each parameter were tabulated and were compared to the KEBS standards, which have been derived from WHO standards. Specific remarks were indicated for each parameter.

RESULTS AND DISCUSSION

Dissolved Oxygen and pH: Dissolved oxygen (DO) is considered a parameter that indicates level of pollution of a water resource [19]. DO usually has an impact on the type of flora and fauna. In this current study, DO ranged between (5.25 to 6.21) mg/L which is within the required KEBS standards. This showed that the underground water quality is good, this finding agrees with the research done by Pandeyi and Tiwari [9]. The pH plays a great role in the chemistry of ground water and is a measure of hydrogen ion levels in the groundwater [20]. Observed pH values in the sampling points ranged from 5.98 to 7.85. Samples from point A had a relatively low pH on average of 5.98. However, pH is generally not a direct threat to human health but long-term intake of acidic groundwater has been reported to result in mineral deficiencies. Therefore, the water from point A may affect human health [21]. However, this argument is open to discussion and further research.

Hardness and Alkalinity: Observed results showed water from Kiwanja Market is hard to very hard. The samples from points A and B had 126 and 150 mg CaCo3/L respectively, indicating water from these points are hard (Table 2). Samples from point C & D had 270 and 210 mg $CaCO_3$/L, which were greater than 181 mg CaCo /L_3, therefore water from these points, are very hard [22]. However, there is no negative impact on health that has been reported on taking hard water [23], in fact taking deionised water in itself is not recommended because it does not have the normal electrolyte balance [24]. For alkalinity, all samples were below the maximum KEBS recommended value of 500mg $CaCO_3$/L.

Nitrates and Turbidity: The results showed a range of 0.05 - 4 mg/L for nitrates that were below the KEBs recommended value of 10 mg/L. However, sample C had a value of 4 mg/L, which could be attributed to leachates from refuse dumped discriminately and septic tanks systems around the sampled point. To some extent, it may also indicate presence of domestic contamination. Another reason could be lack of proper sewerage system. In addition, point sources such as landfills, industrial spillage, Nitrates is an indicator of anthropogenic contamination. Elevated concentration of Nitrates in water used for drinking may be reduced to nitrite which when taken leads to blue baby disease [25]. Turbidity range was 5.57NTU and 6.46NTU for samples from point A and C respectively. This showed high values compared to the KEBS value of less than 5NTU. This phenomenon may have resulted from runoff getting into the shallow wells. In addition, recharge areas with human activities may be a contributing factor [26, 27].

Chloride and Sulphate: Chloride values observed were between 80 - 260 mg/L for all the samples. Sample C had 260 mg/L, which was higher as compared to the KEBS value of 250mg/L. High concentration of chloride indicates high degree of organic pollution [24]. A high level of chloride may cause gastrointestinal problems, irritation, diarrhoea and dehydration [28, 29]. Excessive level of chloride also imparts taste problem [30, 31]. Sulphate sample tests were all within KEBS standards.

Magnesium and Calcium: The mean concentration of magnesium ranged from 21 mg/L at sampling point A to 70 mg/L at sampling point C (Table 1). Sampling point B and D had a mean concentration of 35 and 43mg/L respectively. The concentration of magnesium obtained for all the samples were within the KEBS guideline values. The mean concentration of calcium ranged from 30 mg/L at sampling point A to 98 mg/L at sampling point C. Calcium concentration at sampling point B was found to be 64mg/L and 49 mg/L at sampling point D. The concentrations of calcium in the sampled shallow wells are within the 250 mg/L guideline value prescribed by KEBS.

Potassium and Sodium: The mean concentration of potassium ranged from 1.1 mg/L at sampling point A to 4.0 mg/L at sampling point C (Table 1) sampling point B and D had 3.5 and 3 mg/L respectively. All water samples are within the 200 mg/L guideline value prescribed by KEBS. The mean concentration of sodium ranged from 12 mg/L at sampling point A to 18 mg/L at sampling point C. All water samples were within the 200 mg/L guideline value prescribed by KEBS.

Iron: The mean concentration of Iron in the water was 1 mg/L for sampled water from station C. This result was far higher than the minimum KEBS requirement of less than 0.3 mg/L. it indicates the presents of iron pollution on the ground water. For the other points it was very low such that the equipment used could not detected.

Table 1: Descriptive statistic of Physico-Chemical groundwater parameters for Kiwanja Market compared to KEBs Values

Parameter	Sample A (15m)	Sample B (17m)	Sample C (20m)	Sample D (20m)	KEBS Values	Units	Remarks
Temperature	23	22.5	23	23	20-35	°C	Satisfactory
Colour	Colourless	Colourless	Colourless	Colourless	Not offensive	-	Satisfactory
Odour	odourless	odourless	earthy	odourless	Not offensive	-	C unsatisfactory
Total dissolved solids (TDS)	270	450	696	436	<1500	Mg/L	All samples satisfactory
Turbidity	5.57	3.36	6.46	2.57	<5	NTU	A & C unsatisfactory
Dissolved oxygen (DO)	6.21	5.42	5.25	5.78	>4	Mg/L	satisfactory
pH	5.98	6.35	7.85	6.91	6.5-8.5	-	A, unsatisfactory
Total Hardness	126	150	270	210	<500	Mg/L	satisfactory
Alkalinity	84	108	285	150	<500	Mg/L	Satisfactory
Nitrates	0.05	0.09	4	0.08	<10	Mg/L	Satisfactory
Sulphates	8	10	24	8	<400	Mg/L	Satisfactory
Chloride	80	180	260	150	<250	Mg/L	C Unsatisfactory
Sodium	12	18	20	13	<200	Mg/L	Satisfactory
Potassium	1.1	3.5	4	3	<200	Mg/L	Satisfactory
Magnesium	21	35	70	43	<100	Mg/L	Satisfactory
Calcium	30	64	98	49	<250	Mg/L	Satisfactory
Iron	-	-	1	-	<0.3		C Unsatisfactory

Table 2: Categorisation of Water Sampled hardness

Classification	Hardness in $CaCO_3$ in Mg/L	Sample Category
Soft	0 - 60	Nil
Moderately hard	61 - 120	Nil
Hard	121- 181	Sample A (126), B (150)
Very Hard	≥181	Sample C (270), D (210)

CONCLUSIONS

Physicochemical properties of underground water samples for Kiwanja Market were determined. Most of these properties were within acceptable limits according to KEBS water quality standards. However, samples from km is generally hard and very hard. This requires appropriate treatment be carried out to reduce hardness. In addition, chloride for point C showed higher values than the stipulated amount this might require suitable treatment. Iron for samples from point C was higher than the stipulated amount by 0.7 mg/L. Iron contamination may have originated from natural, industrial or domestic sources [32]. However, iron is essential for haemoglobin and a number of enzymes, its overload may cause a number of health problems such as liver cancer in humans [33]. There is need to develop monitoring plan which should be carried out on regular intervals to mitigate any increase in pollution as well as reduce the values that are high especially water from bore hole C.

ACKNOWLEDGEMENT

The authors are grateful to Kenyatta University for allowing the groundwater samples to be analysed in the various Laboratories. Many thanks to Kimani, Civil Engineering Chief Technician for the assistance he offered.

REFERENCES

1. Balakrishnan, P., A. Saleem and N.D. Malligarjun, 2011. Groundwater Mapping Using Geographical Information Systems (GIS): A Case study of Gulbarga City, Karnataka, India. African Journal of Environmental Science and Technology, 5(12): 1069-1084.
2. Al-Ghamadi, A.Y., M.E.I. Saraya, A.O. Al-Ghamadi and S.A. Zabin, 2014. Study of the Physico-Chemical Properties of Surface and Ground Water. American Journal of Environmental Science, 10(3): 220-235.
3. Usman, Y.M., A. Mohammed, B. Ibrahim and B.A. Saleh, 2016. Assessment of Groundwater Quality Status along River Ngadda in Maiduguri, Nigeria. The International Journal of Engineering and Science, 5(1): 8-14.
4. Krishan, G., S. Singh, S. Gurjar, C.P. Kumar and N.C. Ghosh, 2016. Water Quality Assessment in Terms of Water Quality Index (WQI) Using GIS in Bellia District, Uttar Pradesh, India. Journal of Environmental and Analytical Toxicology, 6(3): 1-6.
5. Ravi, V., G.B.B. Herath, M. Manobavan and S.S. Sivakumar, 2016. An Assessment of Groundwater Quality in Selected Dug Wells in Vavuniya Urban Council Limit through Water Quality Index. International Journal of Scientific and Engineering Research, 7(4): 1517-1526.

6. Ammann, A., 2003. Groundwater Pollution by Roof Runoff Infiltration Evidenced with Multi-Tracer Experiments. Water Research, 37: 1143-1153.
7. Sapri, N.A.S.M., M.P. Abdullah, S. Mat, R. Elfithri and W.M.A.W.M. Khalik, 2016. Evaluation of Hydrochemistry Variation in Water Quality of Cempaka Lake, Malaysia using Multivariate Statistical Analysis. Journal of Materials and Environmental Science, 7(12): 4403-4410.
8. Kuroda, K. and T. Fukushi, 2008. Groundwater Contamination in Urban Areas. Groundwater Management in Asian Cities, Eds. Takizawa, S. Springer Japan Publisher, pp: 126-149.
9. Pandeyi, S.K. and S. Tiwari, 2009. Physico-Chemical Analysis of Ground Water of Selected Area of Ghazipur City - A case study. Nature and Science, 7(1): 17-20.
10. Kumar, R., G. Agarwal, V. Gupta, R. Gupta and R. Rastogi, 2010. Ground Water Quality Assessment of Moradabad District for Drinking Purposes. Journal PAS (Physical Science), 16: 119-128.
11. WHO, 2017. Weekly Epidemiological Record., 92(36): 521-536.
12. Ali, M, A.R. Nelson, A.L. Lopez and D.A. Sack, 2015. Updated Global Burden of Cholera in Endemic Countries. Neglected Tropical Diseases, pp: 1-13.
13. Mahagamage, M.G.Y.L. and P.M. Manage, 2015. Mapping Spatial Distribution of Water Quality Parameters Using GIS in Groundwater of the Kelani River Basin, Sri Lanka. In The Proceedings of Academics World 12th International Conference, Singapore 20th December pp: 10-14.
14. Carroll, S., A. Liu, L. Dawes, M. Hargreaves and A. Goonetilleke, 2013. Role of Land Use and Seasonal Factors in Water Quality Degradations. Water Resources Management, 27: 3433-3440.
15. Kurwadkar, S., 2014. Emerging Trends in Groundwater Pollution and Quality. Water Environmental Research, 86: 1677-1691.
16. Kenya Drinking water Quality Standards (1996).
17. UNEP/WHO., 1996. Water Quality Monitoring - A Practical Guide to Design and Implementation of Freshwater Quality Studies and Monitoring Programmes, Eds., Bartram, J. and Balance, R. Chapman and Hall Publishers, pp: 92-110.
18. APHA, 1999. Standard Methods for the Examination of Water and Wastewater. American Water Works and Water Environment Federation.
19. Kinuma, D., C. Qian and T. Yamada, 2016. A Fundamental Study in the Characteristics of Water Quality for Improvement in the Urban closed Water Body. Procedia Engineering, 154: 565-573.
20. Thanapalasingam, V.A., 2012. Pollution Status of the Sungai Skudai River System through Heavy Metals, a Thesis, Faculty of Science Universiti Teknologi Malaysia.
21. Farid, S., M.K. Baloch and S.A. Ahmad, 2012. Water pollution, Major Issues in Urban areas. International Journal of Water Resources and Environmental Engineering, 4(3): 55-65.
22. McGowan, W., 2000. Water Processing, Residential, Commercial, Light Industrial, 3rd Ed. Lisle, IL, Water Quality Association.
23. Hasan, I., S. Rajia, K.A. Kabir and G.A. Latifa, 2009. Comparative Study on the Water Quality Parameters in Two Rural and Urban Rivers Emphasizing on the Pollution Level. Global Journal of Environmental Research, 3(3): 218-222.
24. Sangupta, M. and R. Dalwani, 2008. Determination of Water Quality Index and Suitability of an Urban Waterbody in Shimoga Town, Karnataka. Proceedings of Taal 2007: The 12th World Lake Conference, pp: 342-346.
25. Mjumdar, D., 2003. The Blue Baby Syndrome. Resonance, pp: 20-30.
26. Annalakshmi, G. and A. Amsath, 2011. An Assessment of Water Quality of River Caurey and its Tributaries Arasalar with Reference to Physico-Chemical Parameters at Tanjore DT, Tamil Nadu, India. International Journal of Applied Biology and Pharmaceutical Technology, 3(1): 269-279.
27. Riza, R. and G. Singh, 2010. Assessment of Ground Water Quality Status by Using Water Quality Index Method in Orissa, India. World Applied Sciences Journal, 9(12): 1392-1397.
28. Qadeer, R., 2004. Pollution in Drinking Water, Their sources, Harmful Effects and Removal Procedures. Journal of Chemical Society of Pakistan, 26: 293-301.
29. Shakirullah, M., I. Ahmad, K. Mehmood, A. Khan, H. Rehman, S. Islam and A.A. Shah, 2005. Physico-Chemical Study of Drinking Water from Dir Districts. Journal Chemical Society of Pakistan, 27(4): 374-387.
30. Khan, M.E. and A. Ahmed, 2001. Physical, Chemical and Biological Parameters in Well Waters of Karachi and Their Health Impacts. Journal-Chemical Society of Pakistan, 23(4): 263-268.

31. Jain, P., J. D. Sharma, D. Sohu and P. Sharma, 2005. Chemical Analysis of Drinking Water of Villages of Sanganer Tehsil, Jaipur District. International Journal of Environmental Science Technology, 2: 373-379.
32. Michael, T.A., T. Aderemi, O. Christian, A. Adedayo, Y. James and A. Salamatu, 2016. Multivariate Analysis of under Ground Water Pollution Sources in Agbabu Bitumen Belt. American Chemical Science Journal, 12(4): 1-10.
33. Kumar, V., K.P. Bharti, M. Talwar, K.A. Tyagi and P. Kumar, 2017. Studies on high Iron content in Water Resources of Moradabad District (UP), India. Water Science, 31: 44-51.