Asian Journal of Environment & Ecology

10(3): 1-9, 2019; Article no.AJEE.51254
ISSN: 2456-690X

Effect of Dumpsite on Water Quality of Shallow Wells: A Case Study of Nasarawa Town, Nasarawa State, Nigeria

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Authors' contributions

This work was carried out in collaboration among all authors. Author CEA designed the study. Author IO wrote the protocol and wrote the first draft of the manuscript. Authors EAO and YA managed the analyses of the study. Authors CEA and IO managed the literature searches. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/AJEE/2019/v10i330117
Editor(s):
(1) Dr. Wen-Cheng Liu, Professor, Department of Civil and Disaster Prevention Engineering, Taiwan Typhoon and Flood Research Institute, National United University, Taiwan.
Reviewers:
(1) Hideharu Shintani, Chuo University, Japan.
(2) Hiren B. Soni, Institute of Science and Technology for Advanced Studies and Research (ISTAR), India.
Complete Peer review History: https://sdiarticle4.com/review-history/51254

Original Research Article

Received 01 July 2019
Accepted 04 September 2019
Published 28 September 2019

ABSTRACT

Municipal solid waste management has emerged as one of the greatest challenges facing environmental protection agencies in developing countries. Water for drinking, cooking and bathing exposes people, especially young children to a wide range of health risks, including diarrheal diseases. This paperis aimed to study the physio-chemical and bacteriological qualities of water samples collected from the wells close to dumpsites in some selected location of Nasarawa Local Government Area, Nasarawa State. From the research, waste dumps which are located

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indiscriminately in Nasarawa town have strong influence on shallow groundwater samples. The physico-chemical and bacteriological properties of the water samples collected from wells fall short of WHO standard. Also, a significant difference was observed between these parameters value in wet and dry seasons. Heavy metals were also detected in the water samples above the acceptable range as recommended by WHO. Significant difference in value of electrical conductivity between wet season and dry season is attributed to the increase in water volume in the well which reduces the salt concentration. Diseases related to drinking non portable water was the most reported cases in all the clinics visited in Nasarawa Local Government Area and this might be as a result of people of this community drinking from these water sources. It was recommended that shallow well should be well lined likewise located far away from dumpsite and latrine, water from these sources should undergo so level of treatment before consumption.

Keywords: Shallow well; dumpsite; Nasarawa Local Government Area; Nigeria.

1. INTRODUCTION

Population increase and economic development lead to massive amounts of solid waste generation by the settlers of the urban areas [1]. Municipal solid waste is usually generated from human settlements, small industries and commercial activities [4].

In Nigeria, the rate of urbanisation characterised by high population concentration, increasing industrial and agricultural activities coupled with environmental pollution/degradation and indiscriminate disposal of all kinds of wastes are perceived to pose serious pollution threats with all its associated health hazards on groundwater quality especially in urban areas [5]. This concern has attracted overwhelming attention of researchers in different parts of Nigeria. This borders on the fact that the public or municipal water supply is inaccessible to a large proportion of urban dwellers, and even where available the supply is highly inadequate, unreliable and irregular [15,16]. Consequently, there is high dependency on untreated groundwater abstracted through hand dug wells and borehole systems [9]. According to Forster et al. [6] urbanization affects the quality and quantity of underlying sub-surface water by radically changing the pattern and rate of recharge, initiating new abstraction regimes and adversely affecting the quality.

In Nigeria, Nasarawa to be precise, the prevalence rate of many dumpsite existing among human dwellings multiplies by the day and it is one of the reasons for the contamination of shallow groundwater which in turn causes the outbreak of a number water borne diseases.

2. MATERIALS AND METHODS

2.1 Study Area

The study area for this project is Nasarawa Town, located in Nasarawa Local Government Area. It falls is between latitude 8º56ʹN to 8º97ʹN and longitude 7º34ʹE to 7º69ʹE situated in the North Central region of Nigeria. It shares boundaries with Abuja, the Federal Capital Territory to the west, Kokona Local Government Area to the east, and Abaji Area Council of Abuja.

Five out of numerous dumpsites in the town were visited, average composition of the waste was studied. Three shallow wells close to each of the assessed dumpsites were also identified.The parameters of the wells like depth during wet and dry season, distance from waste dumps, diameter and lining and cover materials were also assessed. Water samples were collected from each of the fifteen wells selected during the peak of wet season (August, 2016) and during the peak of dry season (March, 2017).

Table 1. Analysis methods for chemical parameters

Parameter	Method	Reagent Pillow	Wavelength (nm)	Reaction time (min)
Nitrate	Cadmium Reduction Method	NitraVer 5	50	5
Arsenic	Quatofix Method	Arsenic 1 and 2	Nil	20
Copper	Bicinchrominate Method	cuVer 1	20	2
Chromium	1,5 Diphenylcarbohydrazide method	ChromaVer 3	13	5

Source: Hach datalogging colorimeter procedure manual, (2000)

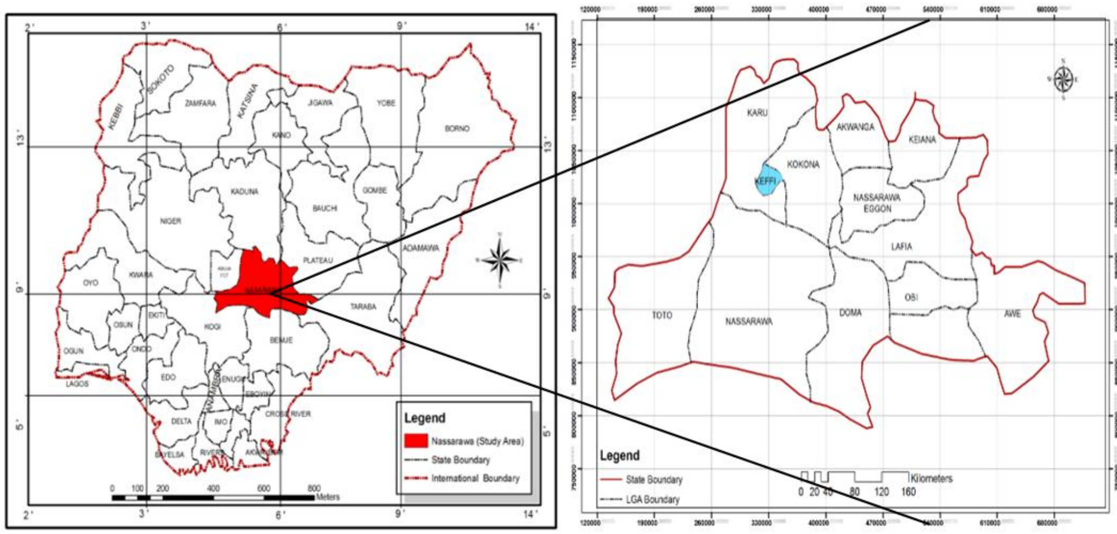

Fig. 1. Location map of the study area

The samples were taken to laboratory for analysis at Federal Polytechnic, Nasarawa State. The parameters analysed for were some physical, chemical and bacteriological parameters using AOAC [7] methods. Composite soil samples were also taken from the well sites to be used for soil hydraulic properties determination.

3. RESULTS AND DISCUSSION

3.1 Aquifer and Soil Hydraulic Properties of the Study Area

Table 2 presents the hydraulic properties of composite soil samples collected from the well sites and other climatic and aquifer data collected from meteorological centres of Federal Polytechnic.

3.2 Physical Conditions of the Shallow Wells Sampled

The results of the physical conditions of the wells are as presented in Table 3.

3.3 Components of Wastes from the Dumpsite

The components of wastes from the five (5) dumpsites are represented in percentages in Table 4. From the table, it shows that Packaging Materials contributes that largest percentage of waste in all the dumpsites.

3.4 Parameters of the Water Samples from the Shallow Wells

Tables 5 and 6 present the concentration of parameters obtained from the analysis carried out on the water samples during the dry and wet seasons respectively. Allowable maximum values for each of the parameters were also presented boldly at the top of each table for comparison.

From Tables 5 and 6 It was discovered that some of the parameters have elevated values in the wet season more than in the dry season and the reason may be attributed to many factors listed by Adeoye et al. [2] as runoff and the lower

Table 2. Climatic and aquifer conditions in Nasarawa

Climatic factors	Minimum	Maximum
Annual Precipitation	1000 mm	1350 mm
Daily Sunshine Hours	6.6	9.4
Average temperature	190 C	410 C
Evapo-transpiration	25 mm	93 mm
Hydraulic Conductivity (K)	0.22 m/day	0.31 m/day

Table 3. Physical properties of the well water

Dump sites	Wells	Depth to bottom (m)	Depth–water (m) (m)		Diameter (m)	Distance from dump (m)	Lining	Cover	Head wall height (m)	Approx. population served
			Dry season	Wet season						
Gwandara	1	6.2	5.8	4.4	1.0	53.0	stone	Steel	0.8	224
	2	7.2	6.4	3.1	0.9	82.3	No	steel	1.0	213
	3	6.8	5.4	1.9	0.8	30.6	No	wood	No	88
Living Faith Church Area	1	8.1	7.7	3.5	0.9	77.6	No	Steel	0.74	218
	2	9.3	6.2	4.1	0.9	58.1	Concrete	No	0.78	267
	3	10.8	7.6	4.4	1.1	41.3	No	No	1.2	97
Piyanku	1	10.0	6.0	3.6	1.0	83.6	Concrete	Wood	0.81	98
	2	17.0	12.4	8.9	1.0	41.0	Concrete	Steel	0.94	61
	3	15.4	11.6	5.8	1	34.6	No	No	No	256
FPN	1	7.3	6.2	3.1	0.9	56.8	Concrete	Steel	1.2	128
	2	8.1	5.5	4.5	0.9	45.0	No	steel	1.2	134
	3	6.2	4.1	2.7	1.0	60.4	stone	Wood	0.51	199
Magistrate Court Area	1	8.0	7.0	3.9	1.0	25.2	No	No	0.26	187
	2	8.1	6.1	3.6	0.9	74.7	concrete	Wood	1.1	179
	3	11.6	9.1	5.0	1.0	40.2	No	No	No	133

Table 4. Components of wastes obtained from all the dumpsites visited

	Glass (%)	Sanitary pads and diapers (%)	Wood & papers (%)	Packaging materials (%)	Textiles (%)	Hospital waste (%)	Other (%)
Gwandara	8	8	12	35	12	15	12
Lfc	10	11	9	31	11	21	7
Piyanku	5	16	5	29	14	27	4
Fpn	7	13	8	30	10	26	6
Migistrate court	4	8	17	38	11	19	3

Table 5. Physico - chemical properties of well water samples in the dry season

Dumpsites	Wells	Colour (Pt.Co.)	FC (cfu/100 ml)	FS (cfu/100 ml)	pH	EC (µS/cm)	Turbidity (NTU)	TDS (mg/l)	FRC (mg/l)	Nitrate (mg/l)	Arsenic (mg/l)	Chromium (mg/l)	Copper (mg/l)
WHO (2011) (STD)		**15**	**0.00**	**0.00**	**6.5-8..5**	**1000**	**5**	**500**	**0.2**	**50**	**0.01**	**0.05**	**2.00**
Gwandara	1	6.2	16.9	12.10	7.4	1140.9	0.69	160.2	0.32	98.3	0.04	0.18	2.98
	2	9.4	63.9	45.25	5.6	1171.6	0.75	149.3	1.75	98.5	0.00	1.23	5.50
	3	33.2	36.3	24.1	6.8	933.8	22.7	190.6	0.65	128.5	0.43	0.14	3.51
LFC	1	21.1	0.67	0.28	8.1	916.2	4.78	145.3	0.99	39.7	0.31	0.33	4.20
	2	11.4	1.20	0.92	6.8	844.3	1.43	166.4	0.78	8.31	0.38	0.35	3.91
	3	14.6	0.00	0.00	6.6	1117.4	0.88	196.3	1.58	15.4	0.03	0.56	4.22
Piyanku	1	6.1	0.34	0.12	7.1	722.8	0.98	109.3	1.45	82.8	0.17	0.17	2.17
	2	3.9	0.11	0.03	7.0	934.2	29.4	54.2	0.69	153.6	0.38	0.32	3.39
	3	5.6	0.34	0.12	6.9	1117.9	17.6	59.3	2.21	78.6	0.37	0.91	1.24
FPN	1	6.9	18.90	12.16	6.9	1216.2	23.2	22.4	1.33	110.0	0.42	0.00	3.25
	2	16.2	13.12	10.0	6.2	1190.0	3.9	60.4	0.85	134.9	0.22	0.27	0.46
	3	4.3	12.21	9.61	7.1	903.1	12.5	11.3	3.42	19.6	0.19	0.22	0.00
Magistrate Court	1	7.3	0.00	0.00	5.9	545.2	13.1	229.1	1.22	15.8	0.03	0.03	6.32
	2	12.8	0.15	0.00	6.2	645.9	14.2	36.3	3.84	23.5	0.00	0.06	7.12
	3	6.2	0.00	0.00	6.7	911.0	16.8	88.0	0.75	153.6	0.12	0.03	3.12

FC: Faecal Coli form, FS: Faecal streptococci, EC: Electrical Conductivity, TDS: Total Dissolved Solid, FRC: Free Residual Chlorine

Table 6. Physico - chemical properties of well water samples in the wet season

Dumpsites	Wells	Colour (Pt.Co.)	FC (cfu/100 ml)	FS (cfu/100 ml)	pH	EC (µS/cm)	Turbidity (NTU)	TDS (mg/l)	FRC (mg/l)	Nitrate (mg/l)	Arsenic (mg/l)	Chromium (mg/l)	Copper (mg/l)
WHO STD		**15**	**0.00**	**0.00**	**6.5-8..5**	**1000**	**5**	**500**	**0.2**	**50**	**0.01**	**0.05**	**2.00**
Gwandara	1	16.2	22.3	14.2	7.44	621.9	4.58	511.2	0.33	103.7	0.03	0.51	6.21
	2	19.4	103.6	70.6	5.69	261.6	11.44	699.3	1.79	96.3	0.06	1.45	12.90
	3	60.2	76.3	33.6	6.8	263.8	17.90	398.5	4.65	334.9	0.00	0.22	4.21
LFC	1	24.1	1.22	4.28	7.8	656.2	16.21	347.8	1.34	88.5	0.63	0.54	5.23
	2	12.3	1.35	0.99	6.9	114.3	5.34	299.0	0.98	13.2	0.41	0.34	6.01
	3	14.7	2.61	0.00	6.1	247.4	4.88	570.5	2.43	61.9	0.12	0.72	4.99
Piyanku	1	6.6	4.22	0.44	7.2	102.8	2.24	180.3	2.35	147.9	0.04	0.38	3.47
	2	4.3	1.41	0.00	7.0	124.2	30.10	537.9	1,34	222.0	0.84	0.39	13.21
	3	7.9	2.33	1.23	6.6	497.9	12.80	606.6	1.78	178.6	0.32	0.95	4.48
FPN	1	8.2	27.35	18.8	6.7	126.2	25.44	87.4	1.56	313.9	0.96	0.02	4.32
	2	13.2	18.20	16.09	6.1	790.0	6.90	100.1	2.66	443.0	0.61	0.33	1.23
	3	5.1	18.29	12.2	7.2	263.1	13.41	11.70	4.03	86.7	0.79	0.29	0.02
Magistrate	1	17.3	1.58	0.00	5.8	127.2	16.22	403.0	2.16	33.0	0.00	0.07	5.21
Court	2	11.3	2.54	0.00	6.2	185.9	11.90	675.9	.973	18.0	0.00	0.05	8.46
	3	12.1	0.00	0.12	6.8	211.0	18.21	148.2	1.28	281.0	0.44	0.09	4.23

FC: Faecal Coli form, FS: Faecal streptococci, EC: Electrical Conductivity, TDS: Total Dissolved Solid, FRC: Free Residual Chlorine depth of shallow wells during wet season which may not have allowed the pollutants to get filtered of while passing through the soil media.

3.5 Turbidity and pH

Turbidity in drinking-water is caused by particulate matter that may be present from water source as a consequence of inadequate filtration. These particulates can protect microorganisms from the effects of disinfection and can stimulate bacterial growth [8]. In all cases where water is disinfected, the turbidity must be low so that disinfection can be effective. No health-based guideline value for turbidity has been proposed; however, it should be below 5.0 NTU for effective disinfection. From the results only few samples have their turbidity value below the acceptable value. Some forms of primary treatment like flocculation and coagulation therefore need to be carried out on this water sources before any further disinfection treatment can be done, otherwise, high turbidity values will shield the pathogenic organisms from chemicals and render the treatment ineffective [13,14].

3.6 Total Dissolved Solid and Electrical Conductivity

There is no evidence of any epidemiological reaction at high level of TDS, but water becomes unpalatable and may lead to corrosion of containers [10]. Consequently, WHO [3] set the highest permissible values of 1000 mg/L. The palatability of water with a TDS level of less than 600 mg/L is generally considered to be good. From the results, the water samples from the wells have very low while some are higher than allowable limits. Electrical conductivity is the ease to which a substance allows free flow of electricity through the ions in electrolytes example of water sample [11]. The Nigerian Standard for Drinking Water Quality has set a maximum permissible level of the conductivity to be 1000 µS/cm. Any level above this can pose health risk of defective endocrine functions and also total brain damage with prolonged exposure [8]. The water samples have their EC very close to recommended values. The high value of EC may lead to defective endocrine functions if used for drinking purpose [17-19].

3.7 Nitrate

Nitrate is a nitrogenous compound that when it is in excess in our drinking water can cause reduction of oxygen capacity of blood, shortness of breath and blueness of skin. The Nigerian Standard of Drinking Water Quality has set 10 mg/L for Nitrate. It has a WHO guideline value of 50 mg/l and if exceeded it is regarded as one of the causes of methaemoglobinaemia (Blue Baby Syndrome) in infants [12] as well as a potential risk of stomach cancer in adults [11]. High concentration of nitrate in shallow groundwater can probably due to poor sanitation other agrochemical use. High nitrates concentrations in drinking waters point often towards contamination [2]. Therefore, water sources with high nitrate values need to be checked for bacterial contamination [20,21].

3.8 Heavy Metals

Results from the analysis shows that thirteen (13) out of the fifteen (15) shallow wells contain Arsenic, which is detrimental when consumed, other heavy metal like cupper and chromium was also found in significant quantity exceeding the WHO [23,24] recommended value.

3.9 Bacteriological Quality of the Water Samples

Zero values are recommended feacal coliform and feacal streptococci in drinking water. Results from the study indicate that the samples analyzed had their bacteriological far above the recommended limit and are therefore not fit for drinking without treatment. Researchers have reported that proximity of shallow wells to pit latrines and waste dumps contributed highly to the bacteriological contamination to groundwater [22]. However, the possibility of contamination is less with the sources which are properly covered at the top and lined from outside of the well. The high coliform count could be attributed to the proximity of the wells to pollution sources such as open defecation and waste dumps which encouraged quick migration of contaminants, especially those located upstream of the shallow wells. Research shows that these bacteria cannot withstand high temperature [3]. Therefore, boiling of contaminated water is a cheap but effective option for water users before use. The presence of coliform provides evidence of recent feaces contamination and the detection should lead to further action. Coliform are found in high concentration in human and animal feaces and rarely found in the absence of feacal pollution.

The medical officers in charge of the clinics in Nasarawa Local Government Area was visited and it was asserted that water-borne diseases especially dysentery and diarrhea was one of the most reported cases. It was also reported that within the last five years more than a fifty (50) cases of Blue baby syndrome have been recorded generally.

4. CONCLUSION AND RECOMMENDATIONS

Poor waste management and disposal systems (agriculture, municipal and industrial) which has been identified as one of the major environmental problems are still being practiced in most part of this country Nigeria. From this study, waste dumps which are located indiscriminately in Nasarawa town have strong influence on shallow groundwater samples. The physico-chemical and bacteriological properties of the water samples collected from wells fall short of WHO [23] standard. Also, a very sharp difference was observed between these parameters in wet and dry seasons. Heavy metals were detected in the water samples in quantity higher than maximum contaminant level (MCL) recommended by WHO [24].

High bacteriological parameters detection in the water samples especially during the wet season may clearly confirm the reason why water borne diseases (WBD) are rampant in Nasarawa Town.Dumpsite might be one of the prevailing contaminant of the wells. These water users should then be protected from danger of WBD by ensuring good waste management practices and water from these sources is not fit for drinking, these water are to undergo appropriate treatment methods before drinking to avoid diseases.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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(Accessed September, 2017)

Peer-review history:
The peer review history for this paper can be accessed here:
https://sdiarticle4.com/review-history/51254