

Effect of Open Refuse Dumpsite on the Quality of Underground Water Used for Domestic Purposes in Ado-Ekiti, Nigeria - A Public Health Awareness Study

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Abstract

The quality of underground water is compromised by the indiscriminate dumping of waste in the environment and contamination by leachate. The effect of the dunghill leachate on the physicochemical and microbial quality of water samples collected from closest wells to the municipal waste disposing sites were investigated using standard chemical and microbiological methods. Different antibiotics (amoxicillin, amoxicillin clavulanic acid, chloramphenicol, cloxacillin, cotrimoxazole, erythromycin, gentamicin, nalidixic, nitrofurantoin, ofloxacin, streptomycin and tetracycline) were screened against two indicator organisms (*Enterococcus faecalis* and *Escherichia coli*) isolated from water samples. The distances of the wells from the foot of the nearby dump sites ranges from 85.3 to 25.7 m. The pH values of the water samples ranged between 5.86 and 7.84. The turbidity of the water samples was also between 1.0 and 8.0 NTU. Five heavy metals were detected in the water samples with zinc having the highest value. The observed concentrations of metals in the wells water samples were presented as Zn>Pb>Cu>Co>Hg. The total bacterial count of the water samples from the well ranged between 2.2×10^1 cfu/ml and 2.51×10^2 cfu/ml while the coliform load ranged from 9.1×10^1 cfu/ml and 1.3×10^1 cfu/ml. Cloxacillin and tetracycline were not effective against the most of the *E. faecalis* isolates. Only 48 (71.66 %) and 53 (88.33 %) *E. faecalis* strains were sensitive to cloxacillin and tetracycline, respectively. Gentamicin was most effective on *E. faecalis*. Out of the eight antibiotics tested, ofloxacin was most effective against the pathogen. The quality of the water samples were below the tolerable level and unfit for domestic purposes.

Keywords: Dumpsites, Well, *Enterococcus faecalis*, *Escherichia coli*, Heavy metals, Indicator organisms, Antibiotic resistance

1. Introduction

Most Nigerian cities are epitome of urban decay and characterized by poor housing, sanitation and public health infrastructure (Akinbiyi, 1992). Their erratic growth of housing units coupled with rapid population explosion has resulted in environmental health hazards (Adefemi & Awokunmi, 2009).

Wastes are generated from human activities and in most cases not properly managed (Aurangabadkar et al., 2001) in most Nigerian cities (Adefemi & Awokunmi, 2009). This leads to low environmental quality which accounts for 25% of all preventable ill health in the world (WHO, 2002). In most cases, wastes are collected and disposed off in uncontrolled dumpsite sited near residential buildings. These wastes are heaped up and/or burnt, polluting water resources and air (Akpan, 2004; Uffia et al., 2013).

Waste generally leads to proliferation of pathogenic microbes and heavy metals which can transfer significantly to the environment (Adefehinti, 2001). Leachates from dumpsites constitute a source of heavy metal pollution to both soil and aquatic environments (Ali & Abdel-Satar, 2005). This may have detrimental effects on soils, crop and human health (Bahnasawy et al., 2011).

Most human activities revolve round water, and its quality in a long way affect health and the socio-economic development of man. Anthropogenic factors contribute highly to contamination of both surface and underground water (Singh & Mosley, 2005). Water contaminants have been mainly biological and chemical in origin (Smith, 2003; Uffia *et al.*, 2013). The quality of underground water could be compromised if it is not distant from constant source of pollution.

Like many cities in Nigeria, Ado-Ekiti is faced with the problems of improper collection, handling and disposal of domestic wastes. The aim of this work is to determine the effects of waste dumpsites within Ado-Ekiti metropolis on the physicochemical properties of the nearest wells and the antibiotic resistance of the indicator bacteria isolated from the water.

2. Materials and Methods

2.1 Study Area and Collection of Water Samples

Twenty different sites for dumping of the domestic wastes were identified within Ado-Ekiti metropolis (7° 40' N, 5° 15' E). Water samples were collected aseptically using sterile sampling bottles from the nearest well to each of the dumpsites. The distance between the well and the feet of the dumpsites, and the depth of the well was measured to the nearest meter.

2.2 Determination of Physicochemical and Heavy Metal Content of the Well Water

Water samples were collected in sterile water plastic containers and were taken to the laboratory and analyzed within 3 h of collection. Freshly prepared doubled distilled water was used as control. Water samples were analyzed for physiochemical qualities according to AOAC (2005). Temperature was measured at the point of collection using a Digitron

Thermometer (Model 275-K). Electrical conductivity was measured with a CDM 83 conductivity meter (Radio Meter A/S Copenhagen, Denmark). Turbidity and pH were determined at site using Water Proof Scan 3+ Double Junction (Wagtech International, UK). The level of heavy metals (Co, Cu, Hg, Pb and Zn) in the well water samples were determined by atomic absorption spectrophotometry, Model 403 (Perkin-Elmer, Norwalk, Connecticut, USA). All determinations were made in duplicate.

2.3 Isolation and Identification of Bacterial Isolates

Water samples were collected from wells in sterile containers, from all the located wells. In a sterile environment one milliliter of the samples was introduced into 9 ml of sterile distilled water and gently agitated after which a 10 fold serial dilutions were carried out. One ml of appropriate dilution was aseptically plated, using pour plate technique, on Plate count agar (Oxoid), Bile aesculin azide agar (Oxoid) and MacConkey agar (Oxoid) to determine the total bacterial count, enterococcal load and coliform load respectively. Colonies with dark brown to black hallow on Bile aesculin azide and those with greenish metallic sheen on MacConkey agar were characterized and identified using colonial, morphological and biochemical characteristics as described by Holt et al. (1994).

2.4 Antibiotic Sensitivity Testing

The isolates were grown at 37 °C in Mueller-Hilton broth (Oxoid) for 18 h and diluted to an optical density of 0.1 (0.5 McFarland Standard) and stored at 4 °C. The disc diffusion method was used for susceptibility testing as described by Clinical and Laboratory Standard Institute (2008). The isolates were tested against eight commercial antibiotic disks (Abtek Biologicals Limited) which their concentrations in microgram in the discs were as follows: amoxicillin (25), gentamicin (10), cotrimoxazole (25), amoxicillin clavulanic acid (30), streptomycin (100), tetracycline (30), chloramphenicol (30), cloxacillin (5), erythromycin (15), ofloxacin (30), nitrofurantoin (100) and nalidixic (30).

3. Results

Effect of dumpsite leachate on the physicochemical, mineral and microbial qualities of underground water samples collected from twenty closest wells to municipal waste disposing sites were investigated. The distances of the wells from the foot of the nearby dump sites ranges from 85.3 to 25.7 as shown in Table 1. Most of the physicochemical parameters of the water from the wells were within the acceptable limits of both World Health Organization and Nigerian Standard for Drinking Water Quality for drinking water. The pH values of the water ranged between 5.86 and 7.84. The turbidity of the water samples was between 1.0 and 8.0 NTU. The values of hardness and sulphate in the water samples were higher than the Nigerian Standard for Drinking Water Quality.

Table 1. Attributes of nearest wells to dumpsites in Ado-Ekiti

Location	Distance from Dumpsite (m)	Depth of the well (m)	Well ringing status	Well covering status	Fetcher type
Agric	69.2	12.8	Ringed	Covered	Single
Bawa road	77.1	11.4	Not ringed	Covered	Single
Idemo	85.3	13.6	Ringed	Covered	Single
Idolofin	47.4	10.1	Not ringed	Not covered	Multiple
Ijiku	83.8	15.5	Ringed	Covered	Single
Isato	50.6	8.8	Ringed	Covered	Single
Kajola	28.2	11.4	Not ringed	Covered	Multiple
Mary	40.5	10.6	Not ringed	Covered	Multiple
Immaculate					
Odo-Aremu	72.8	8.2	Plastered	Covered	Multiple
Odo-Iremo	68.2	13.3	Ringed	Covered	Multiple
Oke-Age	26.7	10.5	Ringed	Covered	Multiple
Oke-Apoko	35.3	8.6	Not ringed	Covered	Single
Oke-ila	44.6	12.1	Not ringed	Covered	Multiple
Oke-oriomi	50.7	9.4	Not ringed	Covered	Multiple
Olobe L.A	62.3	13.2	Not ringed	Covered	Multiple
Oloke-meji	25.7	11.5	Not ringed	Covered	Multiple
Olokuta	70.9	13.1	Ringed	Covered	Multiple
Progress FM	58.2	14.8	Ringed	Not covered	Multiple
Secretariat road	55.9	8.4	Ringed	Covered	Single
Simile l'Oluwa	52.3	16.1	Not ringed	Not covered	Multiple
Mean	55.29	11.67			
SD	18.40	2.37			
CV%	33.2783	20.34			

Table 2. Physico-chemical analyses of water samples from well sunk near dump sites in Ado-Ekiti

Parameters	Water samples from well	NSDQW*	WHO**
pH	5.86-7.84	6.5-8.5	6.5-9.8
Chloride (mg/l)	66.49-45.63	250.0	250.0
Hardness (mg/l)	324.6-456.3	150	500.0
Sulphate (mg/l)	235.0-522.0	100.0	400.0
Nitrate (mg/l)	13.0 - 38.0	50.0	50.0
Turbidity (NTU)	1.0 – 8.0	5.0	5.0
Conductivity (µs/cm)	12.2- 23.4	1000.0	20.0
Total suspended Solid (mg/l)	181.6 – 272.2	500	No Guideline value
Total alkalinity (mg/l)	35.50 – 43.56	30-500	30-500
Cobalt (mg/l)	0 – 0.10	Not stated	Not stated

Copper (mg/l)	0.01 – 0.10	1.00	2.00
Mercury (mg/l)	0 – 0.01	0.001	0.006
Lead (mg/l)	0.01 – 0.13	0.01	0.01
Zinc (mg/l)	0.19 – 2.95	3.00	5.00

NSDQW = Nigerian Standard for Drinking Water Quality (2007)

WHO = World Health Organization Standard for drinking water

*Maximum Allowable Limits

Five heavy metals were detected in the water samples. Table 2 shows that zinc had the highest value among the heavy metals detected. Cobalt and mercury were not detected in some of the samples. All the heavy metals screened were within the WHO health based provisional range. The observed concentrations of metals in the wells water samples were presented as Zn>Pb>Cu>Co>Hg. Though the wells were contaminated with heavy metals the values are within the acceptable values. The total bacterial count of the water samples from the well ranged between 2.2×10^1 cfu/ml and 2.51×10^2 cfu/ml while the coliform load ranged from 1.3×10^1 and 9.1×10^1 cfu/ml. The enterococcal load was lower than the load of the *E. coli* in the entire water sample collected. The enterococci-coliform ratio was less than unity (1.00) in all the water from all the well samples (Table 3).

Table 3. Bacterial load of the wells water sunk near dumpsites in Ado-Ekiti (cfu/ml)

Sampling site	Bacterial load				
	Total	Coliform	<i>E. coli</i>	<i>E. faecalis</i>	Enterococci-coliform ratio
Agric olope	200	45	27	7	0.259
Bawa Road	202	89	10	3	0.300
Idemo	111	68	9	2	0.222
Idolofin	121	50	21	18	0.857
Isato	128	47	13	4	0.308
Itikun	251	52	20	4	0.200
Kajola	190	51	29	14	0.483
Mary Immaculate	98	37	13	8	0.615
Odo-Aremu	144	91	9	2	0.222
Odo-Iremo	156	84	23	5	0.217
Oke-Age	190	90	13	6	0.462
Oke-Apoko	217	41	24	2	0.083
Oke-Ila	82	13	9	2	0.222
Oke-Oriomi	48	21	21	4	0.190
Olobe	181	49	10	3	0.300
Olokemeji	22	17	8	6	0.750
Olokuta Agric	43	33	14	9	0.642
Progress FM	129	36	31	15	0.484
Secretariat Road	81	26	7	6	0.857
Simil'Oluwa	204	73	15	5	0.333

Enterococcus faecalis (n=60) and *E. coli* (n=42) isolated from the water samples were subjected to antibiotic susceptibility test. Only 48 (71.66 %) and 53 (88.33 %) *E. faecalis* strains were sensitive to cloxacillin and tetracycline, respectively. Gentamicin was most effective on *E. faecalis* with 15.00 % (n=9) resistance. Each with 92.86 % (n=39) resistance, tetracycline and cotrimoxazole were not effective against *E. coli* strains from the water samples. Out of the eight antibiotics tested ofloxacin (23.81 % resistance) was most effective against the *E. coli* as shown in Table 4, followed by gentamicin with 40.48 % (n=17).

Table 4. Antibiotic resistance of the representative *E. faecalis* and *E. coli* isolated from the well water samples

Antibiotics	Indicator Organisms	
	<i>E. faecalis</i> (n=60)	<i>E. coli</i> (n=42)
Amx	ND	31 (73.81 %)
Amoclav	39 (65.00 %)	34 (80.95 %)
Chl	42 (70.00 %)	ND
Cot	35 (58.33 %)	39 (92.86 %)
Cxc	48 (80.00 %)	ND
Ery	38 (63.33 %)	ND
Gen	9 (15.00 %)	17 (40.48 %)
Nal	ND	29 (69.05 %)
Ofl	ND	10 (23.81 %)
Nit	ND	31 (73.81 %)
Tet	53 (88.34 %)	39 (92.86 %)
Str	45 (75.00 %)	ND

ND = Not determined

4. Discussion

Improper waste disposing system contributes immensely to the contaminations of groundwater. High turbidity of the water samples is due to the infiltration of leachate from the dumpsites into the wells as reported by Ogedengbe & Akinbile (2007). The contaminants are largely soluble compounds and microorganisms (Aderiye et al., 1992; Udoessien, 2004), although the physical parameters of the water samples were within the recommended limits, heavy metals were detected in the water samples. The heavy metals could be from leachates from the dump sites as suggested by Akpan (2004). Heavy metals are not commonly found in water, their presence is largely as a result of environmental contamination (Bahnasawy et al., 2011). They get accumulated and affect different organs and caused several ailments in the body. Their amount in the water depends on pH, temperature, water hardness, standing time of the water among other factors (IPCS, 2003; WHO, 2003). Urban wastes constitute a large source of pollution and have a significant impact on the ecosystem (Adebayo et al., 2007; Edema et al., 2001; Pirsahab et al., 2013).

The entire well water sampled had a total bacterial and coliform load far above the minimum WHO allowable limits for drinking water. The high amount may be due to infiltration from faecal materials and decaying materials from the dumpsites (Balogun & Longe, 1998).

Although water is not a natural habitat for *E. faecalis* and *E. coli*, their presence in well water can be due to faecal contamination as a result of percolation (Wilson, 2005).

The indicators of faecal pollution: *E. faecalis* and *E. coli* play a significant role in intestinal and extra-intestinal diseases (Havelaar & Nieuwstad, 1985). Peter *et al.* (2012) isolated enterococci in 76 out of 100 tested wells water and reported their presence to be as a result of faecal pollution. In this study the *E. faecalis* and *E. coli* isolated from the water samples from the wells were resistant to most first line antibiotics used in clinical practices. There is an increase in the resistance of the two organisms compared to the previous reports. Resistance of *E. faecalis* to amoxicillin/clavulanic acid increased 65% as against 43% reported by David *et al.* (2011). Also resistance to cotrimoxazole rose ranged from 36% to 58.33 % in the recent study. Among the strains of *E. coli* resistance increased from 67% to 73.81%, 20% to 80.95% and 1% to 23.81% to amoxicillin, amoxicillin/clavulanic acid and ofloxacin, respectively. The variation in the resistance pattern may be due to prior exposure to antimicrobial agents or heavy metals.

Apart from hardness and sulphate, the values of physicochemical parameters were within the set standard of Nigerian Standard for Drinking Water Quality. The nearness of the wells to the dumping sites affects the quality of the water from the wells. There is possibility of movement of resistant pathogens from the leachate from the dumpsites into the well. A relatively high prevalence of resistance among the indicator organisms to first line antibiotics than the previous reports was observed in this study.

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