Normal is the most appropriate model for the mean reservoir inflow at Jebba hydropower dam and thus selected as the best fit model.

The mean reservoir inflow at Shiroro hydropower station has a value of (χ^2_{cal} / χ^2_{tab}), r , R^2 and Se as 0.4791, 0.9900, 0.9900 and 0.0034 respectively for Gumbel extreme value (EVI) type I distribution, while a value of (χ^2_{cal} / χ^2_{tab}), r, R^2 and Se as 0.3540, 1.0000, 0.9900 and 0.025 respectively for Log-Pearson type III (LP_3) distribution. The statistical tests follow the same trend as in the case of Kainji hydropower. That is, the chi-square test suggests EVI, while other tests suggest LP_3 as the best fit model for the peak reservoir inflow data. The indication of a higher value of correlation coefficient (r) for LP_3 also shows that there is a close linearity between the observed and the predicted reservoir inflow. Also, based on the graphical comparison (Fig. 9 and 12) the Log-Pearson distribution model has its curve closer to that of the observed mean reservoir inflow better than that of other probability distribution models. Hence, Log-Pearson type III is the most appropriate model for the mean reservoir inflow at Shiroro hydropower dam and thus selected as the best fit model.

The best fit probability distribution model for the prediction of the peak reservoir inflow at each hydropower station is presented in Table 3

Table 3: Best - fit probability distribution models for mean reservoir inflow

S/N	Hydropower dams	Best – fit models
1.	Kainji	Log – Pearson and Gumbel (EVI type I)
2.	Jebba	Log - Normal
3.	Shiroro	Log - Pearson

CONCLUSION

Various probability distribution models were fitted to the peak reservoir inflow records to evaluate the model that is most appropriate for the prediction of peak reservoir inflow at the three hydropower stations in Nigeria. Various models were established for each hydropower station and the suitable model was selected based on the goodness of fit tests. The log-Pearson type III probability distribution model was found to be appropriate for both the Kainji and Shiroro hydropower dams, while Log-Normal was found to be appropriate for Jebba hydropower dam. The establishment of the best fit probability distribution model would be of useful guide in the prediction of the near future peak reservoir inflow at the three hydropower dams. Also, the Log-Pearson type III model that adequately fit the reservoir inflow at two of the hydropower dams indicates that the inflow data are skewed.

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IMPACT OF WASTE DUMP AND INDUSTRIAL EFFLUENTS ON GROUNDWATER QUALITY AT OLUYOLE INDUSTRIAL ESTATE, BEERE AND BODIJA ESTATE AREA OF IBADAN METROPOLIS

A. O. Adetayo

Federal College of Agriculture, Institute of Agricultural Research and Training, P. M. B. 5029, Moor Plantation, Ibadan, Oyo State.

ABSTRACT

The quality assessment of groundwater in some selected areas in Ibadan metropolis was investigated in this study to evaluate the impact of waste dump and industrial effluents on the groundwater resources and its suitability for domestic uses. In order to achieve the said objectives, six sampling stations were randomly selected which served as representative samples for industrial, commercial and residential areas. Two stations at Oluyole Industrial Estate, two from Beere area, while other two were selected from Bodija housing estate. The water samples collected were analyzed in the laboratory using methods of Ademoroti (1996). The results obtained from the analysis were compared with the World Health Organization standards for drinking purposes. The results showed that despite the large content of sewage and industrial effluents characterized by some of the area, the quality of the groundwater is within the safe limit for drinking purposes. The concentration of Nickel in all the samples collected from industrial and commercial areas was found to be <0.004mg/l while the concentration of Cadmium Lead, Copper, Arsenic and Chromium ranged from <0.003 – 0.004mg/l, 0.02 – 0.42mg/l, <0.004 – 0.04mg/l, <0.004 – 0.003mg/l, and <0.004 – 0.02mg/l respectively. The concentration of heavy metal in ground water from residential areas was not detectable. It is suggested that people living in and around the study area can easily depend on the groundwater for domestic and other uses.

Keywords: Industrial Effluents, Waste dump Site, Groundwater Quality, Water Assessment and Sampling Points

INTRODUCTION

One of or perhaps the greatest unreserved paradox of our computer age is the inevitability of wrestling with the need to advance, develop and better the quality of life on earth without being simultaneously destructing through unfavorable alteration of our environment by direct and indirect effect of changes in the energy pattern, radiation levels, chemical and physical constitution and abundance of organisms called *Pollution* and its associated mechanisms. Our environment in all its spores has been battered and are constantly being threatened by pollutants in the names of discoveries and advancement in modern agriculture, urbanization, industrialization, sciences and technology.

The discharge of effluents into natural waters has been a source of concern in water resources management. One so obvious effect on the receiving water bodies in Nigeria, the Federal Environmental Protection Agency (FEPA) was set up with the responsibilities; one of which is the monitoring the quality of industrial effluents, as a result of which it has set up limits and guidelines on the maximum allowable concentration of effluents that water bodies of Nigeria can accommodate. Pollution of underground water arises most commonly from the percolation of polluted water from the surface and the various action and interaction depending on the degree of protection for underground water.

The groundwater potential of the study area is dependent mainly upon the tectonic situations of the basement complex, that is, the joint pattern and faults, and upon the thickness and composition of the overlying weathering mantle. The presence of joints in the crystalline rock does not however guarantee sufficient groundwater availability since joints sealed by mineral precipitation or by materials such as clay may impede the groundwater flow considerably (Fagoyinbo, 1986).

With the inadequate supply of pipe-borne water in many communities in the country, people have resolved to the exploitation of groundwater to urgument this inadequacy. In the past, lots of lives have been lost due to unavailability of potable drinking water. Scientific researchers in recent times indicated that there have been considerable interest by environmental scientists and engineers to rescue the situation, but much is yet to be accomplished.

This study is aimed at comparing the physicochemical characteristics and heavy metal concentration of groundwater resources at Beere, Oluyole industrial estate and Bodija housing estate areas of Ibadan metropolis with the World Health Organization (WHO) standards for drinking.

MATERIALS AND METHODS

Sampling

Six sampling stations were randomly selected from Oluyole industrial estate, Beere and Bodija housing estate areas of Ibadan metropolis. 10 borehole water samples were collected from each station making a total of 60 sampling points: two sampling stations at Oluyole Industrial Estate, as representative samples for investigation on effects of industrial effluents on groundwater quality, two sample stations from Beere/ Agbeni area, as representative samples on effect of waste dump from commercial areas on groundwater quality , while the remaining two sampling stations were selected from the University of Ibadan Campus and Bodija housing estate respectively to serve as control points. The water samples collected were analyzed in the laboratory using methods of Ademoroti (1996). More so, field surveys were carried out in some of the areas where water samples were collected to know the source of water supply and to verify the facilities used for sanitary.

Treatment of Glassware

All glassware for collection of water samples were soaked in 20% nitric (IV) acid for 24 hours rinsed with water and allowed to dry before use.

Sample Preservation

Water samples collected were stored in refrigerator at 4°C to ensure the integrity of the samples does not change with time before analysis.

Colour Determination

The colours of the groundwater water samples were determined visually with naked eyes

Total Solids (TS)

Evaporation dishes were thoroughly washed and baked at 550oc in muffle finance for 2 hours and collected in a dessicator and weighed until constant weight is attained. 100ml of the samples were accurately measured into these dishes and evaporated to dryness on a steam bath. These dishes were oven-dried at 105^0C for 1hr. and cooled in the dessicator. Alternate weighing and cooling was continued until a constant weight was obtained. The change in weight of the evaporating dishes was used to deduce the residual weight.

Total Suspended Solids (TSS)

Discrete particles in the water samples were determined by filtration through a glass fibre filter. Glass fibre filter weight was determined and filtering of 100ml of water samples were done through the filtration system. The residue left on the glass fibre was washed with distilled water before removing the glass fibre. The glass fibre was dried at 105^0C and weighed. Alternate weighing and cooling continued until a constant weight was obtained.

Total Dissolved Solids (TDS)

Total dissolved solids of the water samples were determined from the difference between the total solids and suspended solids.

Dissolved Oxygen (DO)

Dissolved oxygen (DO) was measured by Winkler method involving iodimetry using starch indicator. The water samples were carefully filled to the brim of glass bottle against the flow of direction avoiding any kind of air bubbling and trapping of air bubble in the bottles. 2ml each of $MnSO_4$ and alkaline iodine azide solution were added respectively well below the surface of water for the fixing of the dissolved oxygen. The bottles were capped immediately and agitated vigorously. On arrival in laboratory, the fixed DO was liberated with 2ml of concentrated H_2SO_4. The bottles were then recapped and shaken to ensure proper mixing.

Determination of Temperature

The temperatures of each of the samples were determined with the use of thermometer.

pH

The pH meter was connected to a battery. The electrode was rinsed with distilled water and standardized first with buffer 4 and then, buffer 9.3. The pH value of the sample was measured.

Heavy Metals

The determination of heavy metal concentration was determined by atomic absorption spectrophotometer (AAS)

Results

The results of physicochemical analysis carried out on water samples collected from Oluyole Industrial Estate (a) and Oluyole extension (b) area are presented in Tables 1. The water samples collected are colourless and odourless with ranges of pH, Temperature, Dissolved Oxygen, Total solid as 6.7 – 6.9, 28 – 29^0C, 2.2 – 2.4mg/l and 200 – 350mg/l respectively.

Table 2 shows the results of heavy metal concentration on groundwater supply at Oluyole industrial estate (a) and Oluyole extension (b). Low concentration of heavy metal were noticed in the samples collected from Oluyole industrial estate while no heavy metal was detected in groundwater samples collected from extension.

The result of the physicochemical analysis carried out on groundwater samples from Beere/Agbeni area showed little variation from those collected from Oluyole Industrial Estate. The only difference noticed was on total solids with a range of 200 – 520mg/l (Table 3). The concentration of the heavy metals was also similar to that obtained from Oluyole Estate except lead with concentration varying from 0.17 to 0.42 (mg/l) (Table 4).

Tables 5 and 6 showed the results obtained from groundwater quality assessment from

University of Ibadan campus (e) and Bodija estate (f). The values of the physicochemical parameters showed no significant difference from that obtained from Oluyole extension area (Table5). No trace of concentration of heavy metal was found on the groundwater supply from the two areas (Table 6).

Table 1: Results of Determined Physicochemical Parameters of Ground Water at Oluyole Industrial Estate and Oluyole Extension Area.

Sampling Points	Colour a & b	Odour a & b	pH		Temp. (°C)		DO (mg/1)		TS (mg/l)		TSS (mg/1)		TDS (mg/1)	
			a	b	a	b	A	b	a	b	a	b	a	b
POINT 1	Colourless	Odourless	6.9	6.9	28	28	2.4	2.6	200	200	100	100	100	100
POINT 2	Colourless	Odourless	6.9	6.9	28	28	2.4	2.5	200	200	100	100	100	100
POINT 3	Colourless	Odourless	6.8	6.9	28	28	2.4	2.5	250	210	100	90	150	120
POINT 4	Colourless	Odourless	6.8	6.8	28	29	2.4	2.5	200	200	100	100	100	100
POINT 5	Colourless	Odourless	6.8	6.8	28	28	2.3	2.4	300	190	150	100	150	90
POINT 6	Colourless	Odourless	6.8	6.8	28	29	2.2	2.4	320	200	150	90	170	110
POINT 7	Colourless	Odourless	6.8	6.8	28	28	2.4	2.5	200	220	80	100	120	120
POINT 8	Colourless	Odourless	6.8	6.8	28	28	2.4	2.5	200	200	80	120	120	80
POINT 9	Colourless	Odourless	6.8	6.8	28	28	2.2	2.5	350	210	100	120	250	90
POINT 10	Colourless	Odourless	6.7	6.8	29	29	2.2	2.5	330	220	100	130	130	90

Table 2: Results of Heevy Metal Concentration of Groundwater at Oluyole Industrial Estate and Oluyoleextension Area (mg/1).

Location	Properties											
	Ni		Cd		Pb		Cu		As		Cr	
POINT 1	<0.004	N.D	0.02	N.D	0.15	N.D	0.02	N.D	0.02	N.D	<0.004	N.D
POINT 2	<0.004	N.D	0.03	N.D	0.15	N.D	0.01	N.D	0.02	N.D	<0.004	N.D
POINT 3	<0.004	N.D	0.03	N.D	0.02	N.D	0.02	N.D	0.02	N.D	<0.004	N.D
POINT 4	<0.004	N.D	0.03	N.D	0.02	N.D	0.03	N.D	0.02	N.D	<0.004	N.D
POINT 5	<0.004	N.D	<0.03	N.D	0.02	N.D	<0.004	N.D	0.02	N.D	<0.004	N.D
POINT 6	<0.004	N.D	<0.03	N.D	0.02	N.D	<0.004	N.D	0.02	N.D	<0.004	N.D
POINT 7	<0.004	N.D	0.02	N.D	0.02	N.D	<0.004	N.D	0.02	N.D	<0.004	N.D
POINT 8	<0.004	N.D	0.02	N.D	0.02	N.D	<0.004	N.D	0.02	N.D	<0.004	N.D
POINT 9	<0.004	N.D	<0.004	N.D	0.02	N.D	<0.004	N.D	0.02	N.D	<0.004	N.D
POINT 10	<0.004	N.D	<0.004	N.D	0.02	N.D	<0.004	N.D	0.02	N.D	<0.004	N.D

Table 3: Results of Determined Physicochemical Parameters of Ground Water at Beere © and Agbeni (F) Area.

Sampling Points	Properties													
	Colour	Odour	pH		Temp. (°C)		DO (mg/1)		TS (mg/l)		TSS (mg/1)		TDS (mg/1)	
	C & d	c & d	c	D	c	d	c	d	c	d	c	d	c	d
POINT 1	Colourless	Odourless	6.9	6.9	28	28	2.2	2.4	200	200	100	100	100	100
POINT 2	Colourless	Odourless	6.8	6.8	28	28	2.3	2.4	210	210	120	100	90	110
POINT 3	Colourless	Odourless	6.8	6.9	28	28	2.3	2.3	200	300	100	150	100	150
POINT 4	Colourless	Odourless	6.9	6.9	28	28	2.4	2.4	220	220	220	100	120	120
POINT 5	Colourless	Odourless	6.7	6.9	28	28	2.0	2.0	350	340	100	200	130	140
POINT 6	Colourless	Odourless	6.8	6.8	28	28	2.2	2.2	380	360	220	100	280	260
POINT 7	Colourless	Odourless	6.9	6.9	29	29	2.0	2.2	200	200	100	80	120	120
POINT 8	Colourless	Odourless	6.9	6.9	29	29	1.8	2.2	250	220	80	80	160	140
POINT 9	Colourless	Odourless	6.7	6.7	29	29	2.0	2.0	500	450	90	80	420	370
POINT 10	Colourless	Odourless	6.7	6.7	28	28	1.8	2.0	520	500	100	80	420	420

Table 4: Results of Trace Metal Concentration of Groundwater at Beere and Agbeni Area (mg/1).

Location	Properties											
	Ni		Cd		Pb		Cu		As		Cr	
	c	d	c	d	C	d	c	d	c	d	c	D
POINT 1	<0.004	<0.004	0.02	0.02	0.17	0.16	0.03	0.02	0.02	0.02	<0.004	<0.004
POINT 2	<0.004	<0.004	0.01	0.01	0.19	0.16	0.04	0.04	0.02	0.02	<0.004	<0.004
POINT 3	<0.004	<0.004	0.03	0.03	0.40	0.02	0.03	0.03	0.02	0.02	<0.004	<0.004
POINT 4	<0.004	<0.004	0.04	0.04	0.38	0.02	0.03	0.03	0.02	0.02	<0.004	<0.004
POINT 5	<0.004	<0.004	0.004	<0.004	0.36	0.02	0.03	0.03	0.02	0.02	0.02	0.02
POINT 6	<0.004	<0.004	0.004	<0.004	0.38	0.02	0.03	0.02	0.2	0.02	0.02	0.02
POINT 7	<0.004	<0.004	0.004	<0.004	0.41	0.02	0.03	0.02	<0.004	<0.004	<0.004	<0.004
POINT 8	<0.004	<0.004	0.004	<0.004	0.39	0.02	0.03	0.02	<0.004	<0.004	<0.004	<0.004
POINT 9	<0.004	<0.004	0.03	0.02	0.42	0.3	<0.004	<0.004	0.02	0.02	<0.004	<0.004
POINT 10	<0.004	<0.004	0.03	0.01	0.41	0.3	<0.004	<0.004	0.02	0.02	<0.004	<0.004

Table 5: Results of Determined Physicochemical Parameters of Ground Water at U.I. Campus (E) and Bodija Estate (f).

	Odour	Colour	Temp. (°C)		TS (mg/1)		SS (mg/1)		DS (mg/1)		DO mg/1		pH	
	e & f	e & f	e	F	e	f	e	F	e	F	e	f	e	f
POINT 1	Odourness	Colourless	28	28	180	180	60	80	120	100	2.6	2.6	6.8	6.8
POINT 2	Odourness	Colourless	28	28	150	200	50	100	100	100	2.7	2.6	6.8	6.8
POINT 3	Odourness	Colourless	28	28	160	180	60	80	100	100	2.5	2.5	6.8	6.9
POINT 4	Odourness	Colourless	28	28	170	170	80	100	90	70	2.6	2.6	6.8	6.9
POINT 5	Odourness	Colourless	28	28	200	200	100	100	100	100	2.4	2.6	6.8	6.9
POINT 6	Odourness	Colourless	28	28	200	200	100	100	100	100	2.5	2.8	6.8	6.9
POINT 7	Odourness	Colourless	29	29	220	220	110	100	90	120	2.5	2.6	6.8	6.9
POINT 8	Odourness	Colourless	28	29	200	220	100	100	110	120	2.5	2.5	68	69
POINT 9	Odourness	Colourless	28	29	100	200	80	120	100	80	2.4	2.5	6.8	6.8
POINT 10	Odourness	Colourless	28	29	200	200	90	110	110	90	2.5	2.5	6.7	6.8

TABLE 6: Results of trace metal concentration of groundwater at U.I. campus (e) and Bodija estate (f) area (mg/1)

Location	Properties					
	Ni	Cd	Pb	Cu	As	Cr
	e & f	e & f	e & f	e & f	e & f	e & f
POINT 1	N.D	N.D	N.D	N.D	N.D	N.D
POINT 2	N.D	N.D	N.D	N.D	N.D	N.D
POINT 3	N.D	N.D	N.D	N.D	N.D	N.D
POINT 4	N.D	N.D	N.D	N.D	N.D	N.D
POINT 5	N.D	N.D	N.D	N.D	N.D	N.D
POINT 6	N.D	N.D	N.D	N.D	N.D	N.D
POINT 7	N.D	N.D	N.D	N.D	N.D	N.D
POINT 8	N.D	N.D	N.D	N.D	N.D	N.D
POINT 9	N.D	N.D	N.D	N.D	N.D	N.D
POINT 10	N.D	N.D	N.D	N.D	N.D	N.D

DISCUSSION

In the investigation on the quality assessment of groundwater in Oluyole industrial estate, Beere and Bodija estate areas of Ibadan metropolis. The differences in the concentration of the ions may be due to the nature and sources of the effluents discharge to the environment. Groundwater samples collected from industrial areas were shown to have highest concentration of heavy metals, this is followed by those collected from commercial areas, while those from residential areas showed no trace of heavy metal concentration. This implies that the effluents discharge from industries have greater contribution groundwater pollution as regards heavy metals concentration. Although the concentration of these heavy metals still fall within the limits set by World Health Organization standards for drinking, it may also be due to the age of the borehole as most of the boreholes are newly dug.. The minimum distance of each bole-hole sunk in the industries is 30m away from the effluents discharge points of these industries.

Groundwater samples collected from areas close to markets (Beere and Agbeni) show relatively higher values of lead, which may be attributed to emission of tetraethyl lead present in the exhaust pipe of automobiles plying the roads within the market places. The concentration of heavy metal in the groundwater samples may be due to nature and heavy sewage disposal in the areas. For instance relatively higher heavy metal content may, through the action of bacteria, influence the concentration of some of anions, Eaton (1989).

CONCLUSION

It is generally accepted that the health of a community depends in large measure on the ample provision of wholesome water supply. It is also true that much ill health has been erroneous and attributed to bad water supply. This ill health varied greatly in character from minor ailments to serious epidemics.

Although some areas of the environment are characterized by large industries and sewage effluents components, the physicochemical and heavy metal composition of the water is within the safe range for drinking set by World Health Organization (WHO). Thus, the water sources are all the sampling points are suitable for drinking. It is hereby concluded that the people staying in and around Ibadan metropolis can easily and totally depend on the ground water for both domestic and other purposes.

Government should intensity efforts at ensuring that manufacturing industry comply with the standard, set for effluents discharged by Federal Ministry of Environment before discharging their waste to the environment.

The present study cannot be regarded as being conclusive thus the quality of groundwater in the study area should be assessed and monitored on a regular basis to ascertain the suitability.

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APPENDIX
GUIDELINE FOR THE INTERPRETATION OF WATER QUALITY

S/N	PARAMETERS	FAO	WHO
1	pH	6.5 - 8.4	6.5 - 8.4
2	Colour		
3	Turbidity		
4	Total Hardness (mg/l)	500	500
5	Calcium Hardness (mg/l)	500	500
6	Magnesium (mg/l)	500	500
7	Sodium (mg/l)	200	200
8	Potassium (mg/l)	50	50
9	Sulphite (mg/l)	250	400
10	Aluminium (mg/l)	5.0	5.0
11	Nitrate (mg/l)	5.0	5.0
12	Iron (mg/l)	5.0	5.0
13	Manganese (mg/l)	0.2	0.2
14	Dissolved silica (mg/l)	4.0	6.0
15	Carbonate (mg/l)	-	-
16	Bicarbonate (mg/l)	-	-
17	Chloride (mg/l)	200	600
18	Zinc (mg/l)	2.0	2.0
19	Copper (mg/l)	0.2-1.0	0.2-1.0
20	Lead (mg/l)	5.0	5.0
21	Boron (mg/l)	<0.7-3.0	0.1-4.0
22	Cobalt (mg/l)	0.05	0.05
23	Chromium (mg/l)	0.10	0.15
24	Cadmium (mg/l)	0.01	0.01
25	Fluoride (mg/l)	1.0	1.0
26	Nickel (mg/l)	0.20	0.20
27	Arsenic (mg/l)	0.10	0.10
28	Coliform count (mg/l)	Absent in 100ml	Absent in 100ml
29	Bacterial (mg/l)	TNC	TNC
30	Total solids (mg/l)	1000	1500

Source: WHO 1993 nd FAO, 1985
TNC: Too numerous to count

EFFLUENT LIMITATION GUIDELINES IN NIGERIA FOR ALL CATEGORIES OF INDUSTRIES

Parameters	**Limit for discharge into surface water**	**Limit for land application**
Temperature	Less than 40^0C within 15 meter of outfall	Less than 40^0C
Colour (Lovibnd Units)	7	-
pH	6-9	6-9
BOD 5 at 20^0C	30(30)	50(50)
Total suspended solids	30	-
Chloride (as Cl)	2,000	2,000
Sulphate (as SO_4^{2-})	600	600
Sulphide (as S^{2-})	500	1,000
Cyanide (as CN-)	0.2	-
Detergents (Linear alkyklate sulphonateas methylene Blue active substance)	1.5	15
Oil and grease	10	20(20)
Nitrate (as N^6_{3-})	20	-
Arseni (as As)	5	10
Barium (as Ba	0.1	5
Tin (as Sn)	5	10
Iron (as Fe)	10	-
Manganese (as Mn)	20	-
Phenolic compounds (as phenol)	5	-
Chlorine (free)	0.2	-
Cadmium	1.0	-
Chromium (trivalent and Malevolent)	Less than 1	-
Copper (mg/l)	Less than 1	-
Lead (mg/l)	Less than 1	-
Mercury	0.05	
Nickel	Less than 1	-
Selenium	Less than 1	-
Silver	0.1	-
Zinc	Less than 1	-
Total metals	3	-
Calcium (as (Ca^{2-})	200	-
Magnesium (as mg^{2+})	200	-
Boron (as B)	5	-
Alkyl mercury compounds Pochlorinated Biphenyl	Not detectable	Not detectable
(PBC)	0.003	0.003
Pesticides (Total)	Less than 0.01	Less than
Alpha emitters, un/ml	10-7	-
Beta emitters, uc/ml	10-6	-
Coliform (daily average)	400MPN/100ml	500 MPN/100ml
Suspended fibre	-	-

Source: Fed. Env. Pr. Ag.