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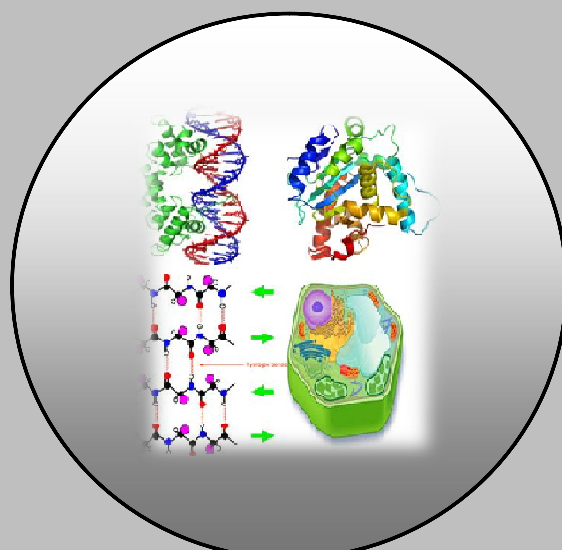

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RESEARCH PAPER

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Assessment of Ground Water Quality, Soil Properties and Nutrient Content of Soil in Areas Close to Municipal Refuse Dump Sites in Makurdi, Nigeria

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ABSTRACT

Makurdi, a fast growing town in central region of Nigeria faces the problem of huge solid waste generation. A study was carried out to assess the suitability of well water close to three refuse dump sites for domestic and irrigation purposes, and also to evaluate the properties of soil (and its nutrients contents) adjacent to the refuse dump sites. Water samples were collected at 100m, 200m and 300m away from refuse dump sites across the three major parts of the town. The water samples were collected during the dry and raining seasons. Soil samples (0-15cm and 15-30cm soil depths) were also collected at 100m, 200m and 300m away from the refuse dump sites across the three locations. Results from the analyzed water samples show that pH, TDS, Total hardness, BOD and COD values were all above WHO acceptable levels for drinking water in all the samples. The ranges of concentration of EC, SO_4, NO_3^{-N} and DO were not above the acceptable levels, however, the study strongly suggest that the chemical quality of well water close to the refuse dump site could fall below WHO acceptable standard. Values of soil organic matter, water holding capacity, N, P, Mn and exchangeable bases were high especially within 100m and thereafter, decreases away from the refuse dump sites. Soil moisture content and Fe values however, increases away from the refuse dump sites. Generally, pollutant in wells and soil fertility decreased with increase in distance from refuse dump sites. Well water close to dump sites should be monitored regularly to ascertain the level of pollution for appropriate treatment. Wells and refuse dump site should not be cited near each other to avoid the risk of water pollution. Soils close to refuse dump site could be exploited for crop production.
Keywords: Well, BOD, COD, Water quality, Soil properties and TDS.

INTRODUCTION

Population growth and urbanization have put a lot of pressure on water resources the world over. Both surface and ground water resources are in high demand in order to meet the needs of the ever-growing population. The conventional water treatment facility thus cannot meet the portable water requirement of most cities. In Makurdi, individuals have resorted to providing their own water supplies by harnessing ground water resources through drilling of bore-holes and wells. Ground water has been as essential source of drinking water for the rural and urban communities. Ground water can be contaminated naturally or though human activities most especially refuse dump (residential, municipal, industrial, commercial and agricultural activities (USEPA, 1994).

Waste water stabilization ponds, sludges, lagoons, barnyard run-off, septic tank teasing fields, deep wells used for waste disposal, solid waste in open dumps and sanitary landfills, solid waste composting sites, industrial refuse, and sewage treatment plant sludge are sources of pollutants that are already dissolved and present in solution. Sufficient water passing through these waste eventually leach-out the pollutants and carry them into the aquifer (Isirimah, 2004). The development of human enterprises produced large amount of domestic waste and other forms of refuse which become a [potential environmental hazard. In Nigeria, municipal wastes are dumped in gutters, steams, dump sites, outside cities, back of houses and market places.

There are reported incidences of pollution of underground water and soil in Nigeria due to solid waste and effluent discharge (Oniawa *et al*., 1995). The nutrient released from decomposition of refuse dump such as nitrates, phosphates and potassium stimulates growth of aquatic plants. They also increase cations and anions in both soil and water (Upendral *et al.*, 2003).

In Makurdi, Benue State, the volume of solid waste generated in Wurukum, Wadata, and North Bank areas has increased significantly over time from an estimated quantity of 15,000 metric tons per year in 1997 to 80,000 metric tons in 20111 because of the increasing population, industrial and economic development. Total assessment revealed that about 80% of the total waste is organic in nature, followed by plastic/nylon 15.75% and 2% metals.

Makurdi metropolis largely depends on untreated well water. To what extent this pollution has affected the water in wells and soil in the area is unknown, hence, the need to monitor the effect of municipal refuse dump on well water quality, soil properties and its nutrient content.

The objectives of the study are to

- evaluate the suitability of well water close to three refuse dump sites for domestic and irrigation purposes,
- evaluate the properties of well water and soils adjacent to municipal refuse dump sites and
- assess the nutrient content of the soils laterally from refuse dump sites.

MATERIAL AND METHODS

The study areas are in Makurdi metropolis of Benue State. Makurdi falls within Latitude $6^0$20N to $7^0$55N and Longitude $7^0$30E and $9^0$40E. The following areas were selected in Makurdi for the assessment:

(i) Wurukum (A)
(ii) Wadata (B)
(iii) North Bank (c)

Field Methods

Soil samples were collected in August 2011, been the highest pick of rainy season in Makurdi when soil moisture content was very close to water holding capacity. In each of the study site, bulk soil samples were collected at 100m, 200m and 300m away from three different refuse dump sites. The sampling covered 0-15cm and 15-30cm soil depths. Samples were taken using soil auger, air dried, sieved though 2mm sieve and stored for analysis.
Water samples were also collected within 100m, 200m and 300m in wells from three refuse dump sites within the same area where soils were collected. Water samples were collected in August 2011 for rainy season and December, 2011 for dry season.

Soil Analysis

Soil moisture content, water holding capacity (WHC) and total porosity were determined gravimetrically. Particles size analysis was determined using hydrometer method. The pH was determined with pH meter (Oyster model 34135A). Soil organic matter by wet oxidation method (Cater, 1993) and available P was extracted with Bray-1-solution and determined spectrophotometrically (Carter, 1993). Exchangeable cations were extracted with one molar (1 M) ammonium ethanate. Na and K were determined by flame emission n Atomic Absorption Spectrophotometer (Buck model 205). Ca Mg and heavy metals were extracted with 0.1m Hcl and determined by atomic absorption spectrophotometer (Buck model 205).

Water Analysis

The pH of water was determined using pH meter (Oyster model 34145A). Total solid (TS), Total Dissolved Solid (TDS) and Total Suspended Solid (TSS) were determined gravimetrically. The dissolved oxygen (DO) was determined at sampling sites using dissolved oxygen meter (model Jenwey 90712). Electrical conductivity was determined immediately the samples arrived laboratory using conductivity meter (Oxygen model 34135A). Alkalinity was determined by titration. Biochemical oxygen demand (BOD) was determined using mercury manometer. Hardness was determined by EDTA complex metric titration (Vogel, 1989). Phosphate samples may be due to depleting calcium ate was also determined spectrophotometrically. Sulphate was determined turbid metrically using Barium chloride gelatin reagent (Vogel, 1989).
Concentration of sodium and potassium was determined in Atomic absorption spectrophotometer by Emission. Ca, Mg and heavy metals were determined with Atomic Absorption Spectrophotometer (ASS) (Carter, 1993). All analysis was carried out in Soil Science Laboratories of Ahmadu Bello University Zaria, and University of Agriculture Makurdi, Nigeria.

RESULTS AND DISCUSSION

The mean values for the physico - chemical properties of the well water sampled close to dumpsites are presented in Tables 1 and 2.

The pH of the well water samples ranged between 5.90 to 6.50 during the dry season and 5.80 to 6.70 during the raining season. The pH increased with increase in distance from the dumpsites. The results further show that the water pH was generally higher during the rainy season than dry season. It was observed that the measured values especially during the dry season were lower than SON Standard Organization of Nigeria), NSDWQ (Nigerian Standard for Drinking Water Quality 2007) and WHO World Health Organization) desirable and maximum permissible limits of 6.50 to 8.50 for potable water. The acidic pH of the water samples may be due to depleting calcium in soil around the dumpsite, oxidation of sulphate deposits, release of aluminum and the presence of organic acids from the dumpsite into the water (Aiyesami *et al.*, 2005). Reduction in pH of water enhances metal solubility and some of these metals in high concentrations are toxic to humans (Ezeigbe, 1989).

The EC values are presented in Tables 1 and 2. Most of the EC values are lower than 1000 µ/cm SON and WHO limit of 900 µs/cm for portable water. This shows that the water is safe for consumption. For irrigation, the water may be consider good, however, moderate leaching as well as moderate salt tolerant. Crops need to be planted.

The amount of TDS obtained in the water samples during the dry season ranged between 60-1200 while that of the rainy season ranged between 110-1340. Most of the TDS values obtained were lower than WHO standard for drinking water of 1000 mg/i. This may be due to the purification of water by non-porous aquifers such as clay by sample filtration and dilution. Significantly, high values of 615 to 800 mg/l were reported by Unyimade and Enekwechi 2004.

The measured values of SO_4 in this study are low compared to 200mg/l SON limit and 400mg/l WHO standard for drinking water. The water therefore, could be considered safe for drinking and other domestic purposes. High content of SO_4 in drinking water may result into catharsis, dehydration and gastro-internal irritation. The Nitrate (NO_3^-N) (Concentrations in the sampled water were lower than the 10mg/l permissive limits stated by SON and WHO 1998. High nitrate in water is injurious to health. The well water is therefore safe for drinking.

The total hardness values obtained were lower than 100mg/l SON and WHO permissible limits for drinking water and other domestic purposes. This may be as a result of lower values of mg and Ca in the water due to leaching. The water hardness generally decreased with increase in distance from the refuse dump sites across the three locations. The dissolved oxygen (DO) values from the results show that the values obtained were all above 2.15 WHO standards. Similar values of DO obtained were reported by Imoisi *et al*. 2012. It was further observed that the DO values increased with increase in distance away from the dump sites across the three locations. This show that DO values close to the dump sites will be low. Very low DO values may result in anaerobic conditions that can cause bad odour in water.

Table1. Physico-chemical properties of well water for dry season.

Parameter	A 100m	A 200m	A 300m	B 100m	B 200m	B 300m	C 100m	C 200m	C 300m
pH	6.15	6.5	5.9	6.18	6.38	6	6.2	6.31	6.4
Do mg/l	4.8	5.5	5.01	5.87	5.25	5.6	5.8	5.7	5.8
TDS mg/l	540	1050	330	1200	180	450	440	1250	60
TSS mg/l	28	54	13	36	12	25	25	37	8
EC	780	1620	510	1850	310	650	610	1880	150
BOD mg/l	160	158	85	165	125	98	93	158	84
Hardness mg/l	56	49	50	58	52	49	56	52	59
Alkalinity mg/l	81	66	64	78	69	67	70	78	61
Ca ppm	40.03	31.22	16.08	36.41	20.09	10.75	51.29	40.44	21.18
Mg ppm	17.96	10.408	6.364	14.051	7.286	4.32	20.075	13.195	9.108
K ppm	7.118	4.228	1.935	5.321	2.113	0.986	9.851	5.731	2.856
Na ppm	4.861	1.974	0.665	2.086	1.001	0.614	7.316	3.081	1.945
Mn ppm	0.477	0.208	0.106	3.136	2.362	1.047	0.656	0.405	0.236
Fe ppm	0.525	0.203	0.086	0.28	0.112	0.056	0.708	0.371	0.195
Cu ppm	0.216	0.105	0.074	0.132	0.096	0.032	0.408	0.151	0.097
Zn ppm	0.341	0.137	0.095	0.205	0.129	0.076	0.531	0.265	0.138
PO_4 ppm	0.042	0.016	0.1	0.054	0.031	0.026	0.063	0.042	0.027
SO_4 ppm	0.03	0.011	0.009	0.035	0.022	0.014	0.046	0.02	0.017
NO_{-3} ppm	0.156	0.079	0.043	0.049	0.026	0.011	0.175	0.086	0.031

A = Wurukum
B = Wadata
C = North Bank

This result probably suggests that wells so close to the dumpsites will have their waters below WHO standard.

Table 2. Physico-chemical properties of well water for rainy season.

Parameter	A 100m	A 200m	A 300m	B 100m	B 200m	B 300m	C 100m	C 200m	C 300M
pH	6.3	6.4	6.7	6.5	6.5	6.4	5.8	5.9	6.6
Do mg/l	5.2	5.4	6	5.1	5.3	6	5.3	5.3	5.9
TDS mg/l	520	430	420	1040	1340	1150	110	290	270
TSS mg/l	30	24	15	32	28	20	18	15	13
EC	750	620	620	1570	2030	1730	410	440	170
BOD mg/l	162	108	98	158	105	97	145	101	85
COD mg/l	45	40	38	49	40	35	48	42	43
Hardness mg/l	57	48	45	56	50	48	58	52	50
Alkalinity mg/l	80	67	65	75	70	65	72	70	62
Ca ppm	12.161	8.53	6.42	10.211	11.341	12041	9.855	15.021	21.321
Mg ppm	5.318	2.816	2.513	3.725	4.025	5.012	3.963	4.289	6.118
K ppm	17.75	0.956	0.789	1.805	1.891	1.921	0.986	2.082	3.481
Na ppm	0.152	0.109	0.2	0.115	0.081	0.231	0.075	0.124	0.305
Mn ppm	12.165	9.841	7.451	15.008	17.321	17.561	12.566	38.42	53.228
Fe ppm	7.221	11.056	6.038	21.34	18.255	19.321	11.351	21.781	29.081
Zn ppm	1.011	0.986	0.988	1.321	1.088	1.058	0.956	5.281	9.83
Cu ppm	0.068	0.105	0.102	0.01	0.008	0.012	0.013	2.102	4.155
NO_{-3} ppm	0.006	0.004	0.001	0.001	0.03	0.003	0.003	0.98	0.102
NH_4 PPM	0.001	0.001	0.001	0.002	0.001	0.001	0.001	0.028	0.039
PO_4 ppm	0.008	0.008	0.007	6	0.009	0.007	0.97	0.97	0.105
SO_4 ppm	0.021	0.008	0.007	0.006	0.009	0.008	0.007	0.85	0.105
Bacterial count per 100ml	5.2x103	5.8x103	$5.3x1^4$	$5.2x1^3$	$5.3x1^3$	$5.3x1^2$	$5.8x1^2$	$5.3x1^3$	$5.3x1^3$

A = Wurukum
B = Wadata
C = North Bank
TSS = Total Suspended Solid
TDS

Results on BOD obtained show a decrease as the distance from the dumpsites increases across the three locations. Increase in N as well as phosphorus towards the dumpsites could be responsible for these findings. The chemical oxygen demand (COD) was only measured during the raining season.

Results from the study show that COD values decreased as the distance from the dumpsites increases. COD is commonly used to estimate the amount of organic substances that will eventually be oxidized to CO_2. The results of this study strongly suggest that the chemical quality (with respect to COD) of wells close to the dumpsites will fall below WHO standard. These results agree with the findings Imoisi *et al.* 2012.

The physic-chemical properties of soil as influenced by refuse dump in the three locations are presented in tables 3 (0 – 15 cm soil depth) and 4 (15 – 30 cm soil depth). From the table, the pH ranged between 6.3 -7.2. The pH decreases as the distance from the dump sites increases across the three locations.

Table 3 Physico-chemical properties of soil samples collected around refuse dump sites (0 – 15 cm).

Parameter	A 100m	A 200m	A 300m	B 100m	B 200m	B 300m	C 100m	C 200m	C 300m
	0-15	0-15	0-15	0-15	0-15	0-15	0-15	0-15	0-15
Sand %	81.4	83.4	83.4	83.4	81.4	83.4	91.4	88.4	91.4
Silt %	3.4	3.8	3.4	1.4	3.4	1.4	1.4	2.4	7.4
Clay%	15.2	13.2	13.2	15.2	13.2	13.2	7.2	9.2	7.2
pH	7.2	6.8	6.3	6.7	6.8	6.7	6.8	6.5	6.5
Moisture %	3.5	4	4.5	3.8	4	4.5	3.2	3.4	3.3
WHC %	5	4.5	3	4.8	3.8	3.2	5.1	4.3	3
Porosity%	4.8	4.6	4.3	4.8	4.5	3.9	4.7	4.5	4
Organic Matter %	4.7	4.97	2.5	2.04	3.91	4.29	2.26	1.88	0.99
P pmm	0.971	1.022	0.92	1.665	1.479	1.861	1.113	1.24	0.983
% N	0.086	0.065	0.081	0.065	0.09	0.086	0.091	0.085	0.106
CaCmol/kg	1.481	0.986	0.9	0.879	1.288	1.305	0.965	0.899	0.8
Mg Cmol/kg	0.381	0.403	0.45	0.365	0.251	0.532	0.301	0.266	0.308
Mn Cmol/kg	0.721	0.681	0.585	1.217	1.305	1.256	1.511	1.409	1.46
Mn ppm	0.721	0.681	0.585	1.217	1.305	1.256	1.511	1.409	1.46
Fe ppm	55.211	60.175	59.123	71.321	69.85	70.311	89.11	90.351	79.521
Zn ppm	0.159	1.326	0.982	0.635	0.911	0.751	1.255	1.187	1.02
Cu ppm	0.76	0.695	0.734	0.731	0.356	0.415	0.322	0.825	0.498
No_{-3} ppm	5.095	4.961	5.085	4.011	5.681	4.962	3.58	3.971	3.063
NH_4 ppm	0.996	1.25	0.978	0.859	0.931	0.866	0.655	0.701	0.611
SO_4 ppm	0.018	0.023	0.018	0.011	0.009	0.013	0.01	0.013	0.01
Exch. Acidity	0.005	0.005	0.007	0.002	0.001	0.003	0.01	0.013	0.009

A = Wurukum
B = Wadata
C = North Bank
WHC = Water Holding Capacity

A correspondent decrease in pH down the soil depths was also observed. The soil pH range observed was generally suitable for growing crops. Water holding capacity of the soil, porosity, organic matter, available P and total N all decreased with increase in distance from refuse dump sites in all the locations. A decreased in these parameters was observed down the soil profile. The high porosity should have resulted from input of organic materials and this would enhance water holding capacity and moisture content.

Table 4. Physico-chemical properties of soil samples collected around refuse dump sites (15 – 30 cm).

Parameter	A 100m	A 200m	A 300m	B 100m	B 200m	B 300m	C 100m	C 200	C 300m
	15-30	15-30	15-30	15-30	15-30	15-30	15-30	15-30	15-30
Sand %	81.4	83.4	83	79.4	83.4	85.4	91.4	89.4	91.4
Silt %	1.4	3.4	3.8	3.4	3.4	1.4	1.4	1.4	1.4
Clay %	17.2	13.2	13.2	17.2	13.2	13.2	7.2	9.2	7.2
pH	7	6.7	6.6	6.8	6.8	6.6	6.7	6.4	6.5
Moisture %	3.6	3.4	4.6	3.9	4.2	4.3	3.1	3.5	3.3
WHC %	5.1	4.4	3.1	4.4	3.7	5	4.2	3	3.2
Porosity	4.8	4.5	4.3	4.7	4.5	3.8	4.6	4.5	4.1
Organic Matter %	4.97	2.57	2.37	4.94	3.84	4.52	1.92	3.36	3.27
P ppm	1.156	1.13	0.975	1.502	1.638	1.925	0.98	1.03	1.056
% N	0.071	0.06	0.075	0.061	0.083	0.07	0.096	0.08	0.102
CaCmol/kg	1.033	0.95	0.966	0.863	1.256	1.2	0.915	0.86	0.875
Mg Cmol/kg	0.367	0.389	0.392	0.358	0.406	0.498	0.295	0.245	0.316
Mn Cmol/kg	0.118	0.116	0.095	0.116	0.113	0.89	0.107	0.103	0.109
Mn ppm	0.41	0.672	0.689	1.117	1.119	1.249	1.386	1.402	1.477
Fe ppm	59.28	58.289	61.222	68.3	72.519	65.31	85.456	89.721	79.735
Zn ppm	1.177	1.3	1.251	0.583	0.813	0.732	1.351	1.105	0.17
Cu ppm	0.695	0.734	0.731	0.356	0.415	0.322	0.73	0.814	0.501
No_{-3} ppm	5.356	4.825	5.198	4.001	5.156	4.953	4.015	3.971	3.886
NH_4 ppm	1.14	1.053	0.988	0.854	0.945	0.833	0.654	0.608	0.622
SO_4 ppm	0.019	0.025	0.021	0.008	0.011	0.011	0.011	0.012	0.01
Exch. Acidity	0.002	0.002	0.004	0.001	0.002	0.001	0.014	0.012	0.011

A = Wurukum
B = Wadata
C = North Bank
WHC = Water Holding Capacity

Moisture content however, increases from 100m to 300m across the three locations. An increase in moisture content was also observed downward. This result disagree with the findings of Ibitoye and Ipinmoroti 2004, who reported decrease in moisture content with increase in distance from the refuse dump site.

The concentrations of cations all decrease with increase in distance from refuse dump sites and decrease down the profile. When compared with FAO standards, mean values of all the cations except that of Na were above their respective critical levels. The values of exchangeable Na are low (<1.34 Cmoil/Kg) therefore, the problem of sodicity is not likely. The values for most micronutrients fall within their critical limits and are therefore, tolerable for crop production. Soils within 100m from refuse dump in the three locations are therefore, considered more fertile than those of the 200m and 300m.

The trend in values of particle size however, could not be related to the variation in the soil chemical properties. This is because the parent material and degree of weathering determines soil texture (Kadeba, 1978).

CONCLUSION

The study revealed that municipal refuse dump had effect on ground (well) water pollution in Makurdi metropolis. However, the degree of pollution is dependent on the distance of the well from the dump site. Wells closer to the dump sites were more polluted than those further away from the dumpsites. Well water close to dumpsite should be monitored regularly to ascertain the level of pollution so that appropriate treatment could be offered.

Wells and refuse dump should not be cited near each other because of the risk of water pollution. Values of soil properties decrease with increase in distance from the refuse dump sites. Soils closes to the refuse dump were more fertile than those further away from the dumpy sites, municipal refuse dump can therefore, be a good store house for plant nutrients. It will provide a good medium for crop growth. Soil close to refuse dump sites may be used for crop production.

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