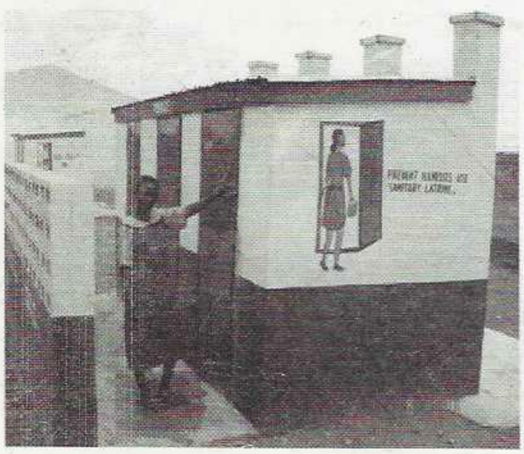
Water and Sanitation Sector Reform:
Empowering LGAs in Achieving National Development Objectives and the MDGs Targets



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EFFECT OF WASTE DISPOSAL ON SHALLOW AQUIFERS IN KPAKUNGU COMMUNITY, MINNA-WEST LGA OF NIGER STATE

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1. INTRODUCTION

Ground water makes up about twenty percent (20%) of the worlds fresh water supply, which is about 0.61% of the entire worlds water, including oceans and permanent ice (MacDonnell, 1996). Ground water is naturally replenished by surface water from precipitation, streams and rivers when this recharge reaches the water table. It is estimated that the volume of ground water comprises 30.1% of all fresh water resource on earth compared to 0.3% of surface fresh water. Ground water can be a long term reservoir of the natural water cycle. It comes from rain, snow, sleet, and hail that soak into the ground. The water moves down into the ground due to gravity, passing through different soil strata it reaches a point of saturation.

The simplest and oldest way of collecting ground water is by digging into ground, hence penetrating the water table. If the quantity of water that can be taken from the hole is not adequate, then the hole must be extended either horizontally or vertically. The method chosen depends on the local geo-hydrology.

If the hole is extended horizontally it becomes an open collecting ditch. On the other hand, vertical extension of the whole makes it a dug or drilled well, or a bore hole. This method can be used when the aquifer is of sufficient thickness, and in any case when the aquifer is more than about 6m below ground level. Dug wells are usually 1m or more in diameter (Wilson, 1990).

The common method for exploiting ground water is by use of well. A water-well is the universal term used for holes or shaft usually vertically excavated in the earth for bringing ground water to the surface. Hole that extends vertically into the water bearing formation below the ground surface are also known as well. The quantity of water that can be drawn from a well is known as yield. Efficient and economical utilization of ground water through wells depend on the design of the well to best suit the water bearing formations. Wells can be classified as shallow and deep wells depending on the depth of the pumping and the water level from ground surface. Wells having a pumping water level at 6m or less from the ground surface are usually classified as shallow or surface wells. While those in excess of 6m in depth as deep wells.

Ground water is valuable resource often used for industry, commerce, agriculture and most importantly for drinking. It is an important source of portable water for rural and medium sized communities in Nigeria (Samaila, 2004). The raw water used for domestic purpose is vulnerable to contamination due to the influence of domestic wastes and other influence. The ground water pollution is mainly due to the process of industrialization and urbanization that has progressively developed overtime, without any regard for environmental consequences (Elendu, 2006).

Protection of ground water is one of the major environmental issues, through water from such sources are suitable for drinking water since it is less exposed to pollutants, which may be present in surface water. Often, surface water needs very expensive chemical treatments before it could be used for drinking. However, ground water could be exploited and used without any chemical treatment.

Water is polluted when it is altered in composition, directly or indirectly as a result of the activities of man. The polluted water becomes less suitable for any meaningful domestic use. Kpakungu as a community 3-5 decades ago was known to be the Minna waste dumping site. This environmental unfriendly act has culminated into the concentration of impurities and other forms of water contaminants flowing as aquifers of most shallow wells within the locality. This scenario has altered the physio-chemical properties of most open wells, thereby making it unhygienic for direct consumption/drinking.

Bacteria may be indigenous or be spread by contaminated surface water (i.e. sewage effluent, leakage from garbage dumps, and other polluted bodies of water) to shallow ground water table. No matter what the source of bacteria is, they (bacteria) and their biological processes affect the quality of ground water. Although water may appear abundant in nature portable water for domestic use is limited. (Metcalf and Eddy, 1978).

Water must be free from organisms that are capable of causing diseases and from minerals and organic substances that could produce adverse physiological effect. Domestic/drinking water should be aesthetically acceptable. It should be free from turbidity, colour, odour and from taste. Drinking water should also have reasonable temperature. Water that meets these conditions is termed "portable": meaning water that can be consumed in any desired amount without concern for adverse effects to health (Elendu, 2006). Domestic water is that water which can be used in private residences, apartment, establishment, houses e.t.c for drinking, bathing, lawn, sprinkling, sanitary and other purposes.

It has become very serious, the problem of refuse disposal at Kpakungu area, Minna Niger state. The refuse dump areas are not far from residential area. This definitely have some impact on the ground water quality over time. Ground water varies in purity depending on the geographical condition of the soil through which it flows. As it flows, it absorbs from the soil some of the soluble gases and salt (UNICEF, 2000).

This study is aimed at investigating the effect of urban refuse disposal in ground water quality in Kpakungu through open shallow wells for its physical, chemical (heavy metals) and bacteriological properties. The level of the properties compared with standard of World Health Organization (WHO, 2007) and Nigeria Industrial Standard (NIS 554, 2007) recommended for domestic drinking water.

1.2 Statement of the Problem

Though, hand–dug wells are serving as the easiest and cheapest source of water supply to most rural homes, it is often polluted or contaminated due to indiscriminate disposal of wastes around areas where such shallow aquifers are found. This environmental unholiness does not only create a flirty serene foul air quality and but also some components of the heterogeneous wastes infiltrate into the soil strata to intercept the subsurface water, thereby affecting its quality.

1.3 Objective of the Study

(i) To investigate the effect of refuse disposal on ground water quality in Kpakungu settlement;

(ii) To assess the physio-chemical, and bacteriological analysis of domesticated open shallow wells within the study site and compare measured values to WHO, 2007 and NIS 554, 2007 standards; and

(iii) To determine whether or not the affected shallow well aquifers in Kpakungu satisfies the WHO, 2007 and NIS 554, 2007 water quality standards for the stated parameters.

2. REVIEW OF RELEVANT LITERATURE

2.1 Water Quality

In Nigeria, 75 percent of the nation's human counts are living in the rural areas in which stream and dug well are their main source of drinking water (Ibrahim, 2004). During dry season surface water are rarely found, while ground water is the only available source.

Foreign substances can readily contaminate water. These pollutants can affect water especially physical, chemical and biological characteristics. Both surface water and ground water are subject to pollution and contamination.

Water quality is closely linked to water use and to the state of economic development. The fact that a well that yields much water does not guaranteed it safe drink from it. Because water being a a universal solvent contains lot of dissolved chemicals. Since ground water moves through rocks and subsurface soil, it has a lot of opportunity to dissolve substances as it moves. For that reason, ground water will often have more dissolve substance than surface water. Even though the ground is an excellent mechanism for filtering out particulate matter, such as leaves, soil and bugs, dissolved chemicals and gases can still occur in large enough concentration in ground water to cause problems.

Having a basic understanding about ground water quality will help ensure that your well is supplying portable water for your household. Along with human activities, water quality is affected by combination of natural processes.

2.1.1 Physical contaminants

The most noticeable alteration of water quality falls within this category. The most common physical contaminants of water are suspended sediments; others include organic materials such as remains of plants and animals, inorganic materials such as celophine, bottles, tins, papers etc and plant residues. Most sediments occur because of soil erosion. Turbidity is easy to see, and thus a likely source of dissatisfaction for the users. It is caused by the presence of suspended materials such as clay, silt, taste and odor can be caused by organic compounds, inorganic salts, or dissolved gases. Formability is usually caused by concentration of detergents. The foam itself does not pose a serious health threat, but it may indicate that other s, more dangerous pollutants associated with domestic waste are also present.

2.1.2 Chemical contaminants

Groundwater is particularly subjected to chemical alteration, because as it moves downward from the surface it slowly dissolves some materials contained in rocks and soils. Chemicals are major source of water contaminants. Some of these chemicals occur naturally in water (Richman, 1997).

The domestic sewage composed of faeces from pit latrines, kitchen laundry waste are the major sources of pollution for the household wells. A chemical analysis is usually necessary for individual water supply sources. These will indicate;

(i) possible presence of harmful or objectionable substances,
(ii) potential for corrosion within the water supply system, and
(iii) tendency for the water to sustain fixtures and clothing.

2.1.3 Bacteriological contaminants

Varieties of water borne diseases are attributed to untreated or inadequate treated surface or groundwater containing pathogenic forms of bacteria. Biological contamination of a ground water may occur when human or animal waste enters into an aquifer. Standard test to determine the safety of groundwater for drinking purposes involves identifying whether or not bacteria belonging to coli form group are present. The recent faecal pollution of water sources are indicated by the presence of coli-bacteria other- wise called Escherichia coli.

2.2 Sources of Water Pollution

Pollution has always been caused by man and animal and natural phenomenon. In developed world, domestic sewage, industrial sewage etc are treated as sewage works to reduce its toxicity and then discharged into rivers and streams having met the set standards e.g 20/30 standard i.e 20mg/l BOD and 30mg/l suspended solid (Sangodoyin and Mson, 1997).

For high density housing it is usually to provide refuse dumps. Often these are merely convenient pieces of spare ground on the road side. Refuse is scattered by wind, goats, lunatics and children. After collection of the main mass of refuse some still remains as a breeding place for flies whose eggs and larvae penetrate the ground. When rain passes through it to the ground there is inevitable pollution floating solids are unsightly, organic matter exerts an O_2 demand and pathogens can create a health danger downstream unless the water table is high.

Water pollution may originate from a point source or from dispersed source. A point source pollutant is one that reaches water from a single pipeline or channel or when harmful substances are emitted directly into a body of water (Terry, 1996), such as sewage discharge or out fall pipe. Disperse sources are broad, unconfined areas form which pollutants enter a body of water. Surface runoff from farms, for example, is a dispersed source of pollution, carrying animal wastes, fertilizers, pesticides, and silt into catchment streams. Point source pollutants are easier to control than dispersed source pollutants as they flow to a single location where treatment process can remove them from the water. Such control is not usually possible over pollutants from dispersed sources. It is best reduced by enforcing proper land use plans and development standards. Types of water pollutant include pathogenic organisms. Inorganic chemicals, sediments etc. sewage is primary source of the first three types.

2.3 Chemical Examination of Water

Chemical composition of water depends on the characteristics of the catchment. Ground water acquires the characteristics of the soil through which it flows. Common chemical pollutants which are of importance in water are given by Samaila (2004).

2.4 Groundwater Contamination from a Waste Disposal

The physical property of an aquifer such as thickness, rock or sediment type and location to a large extent determines whether or not contaminants from land surface will reach the ground water. The risk of contamination is greater for unconfined (watertable) aquifer than for confined aquifers because they usually are nearer or to the land surface and lack an overlying confining layer to impede the movement of contaminants.

2.4.1 Effect of physical contaminant to groundwater quality

There are different types of impurities. These are organic chemicals, inorganic chemicals, turbidity etc. Organic contaminants include various pesticide, industrial solvent etc.

Turbidity refers to cloudiness by very small particles of silt, clay and other substances suspended in water. Even a slight turbidity in drinking water is objectionable to most people.

Colour, taste and odour are physical characteristics of drinking water that are important for aesthetic reason rather than for health reasons. Where high pH causes bitter taste; water using appliances become encrusted. Taste and odour may be caused by naturally occurring dissolved organics or gases. Some well water supplies, for example have a rotten egg odour caused by H_2S.

2.4.2 Effect of bacteriological contaminant to groundwater quality

Coliform bacteria occur naturally in the environment from soils, plants, and in the intestine of humans and other warm blooded animals. Used as an indicator for the presence of pathogenic bacteria, viruses, and parasite from domestic waste.

2.4.3 Effect of chemical (heavy metals) contaminant to groundwater quality

2.4.3.1 Effect of Manganese

Manganese can be a troublesome element in water, even when present in small quantities. It can be deposited in water in the presence of oxygen. Large quantity of manganese is toxic. The concentration of manganese in solution rarely exceeds 1.0 mg per liter in a well-aerated surface water. However, higher concentrations can occur in ground waters subject to reducing conditions. The World Health Organization and the Nigeria Industrial Standard gives a guide level of 0.02 mg per liter and a maximum admissible concentration of 0.2 mg per liter (NIS 554, 2007), 0.5mg per liter (WHO, 2007).

These heavy metals are different chemically and so they cause different problems. Manganese causes dark brown or black stains on plumbing fixtures.

2.4.3.2 Effect of Zinc

Adverse health effects associated with zinc results more from too low an intake rather than from an excessive intake. The adult requirement for zinc is 15mg per day. Drinking water contributes about 3% of this requirement. The WHO 2007 guide level for zinc in drinking water is 3mg per liter. Maximum permissible limit is 15mg per liter. Heavy metal (Zn) standard is based on levels that cause human health problem, staining problem and taste. It is set under WHO, 2007 and NIS 554, 2007 drinking water standards. These standards set up for Zinc, is 3mgper liter.

This metal has negative effect on human health except manganese whose limit is only aesthetic objectives. Its presence in water can cause taste, economic damage and impacts brownish stains to laundry. While the others like zinc also impact an undesirable taste of water. Although effects associated with zinc result more from too low an intake rather than from an excessive intake. But when taken in excess it causes muscular weakness and pain, irritability, and nausea. It also has undesirable taste effect on drinking water and health effect in excess.

The level of zinc associated with these effects is 40mg per liter over a long period.

2.4.3.3 Effect of Chromium

Chromium occurs in drinking water in its +3 and +6 valence states, +3 being more common. The valence is affected by the level of disinfection and presence of reducible organics. It can also enter the environment from old mining operations run-off and leaching into groundwater. The WHO, 2007 and NIS 554, 2007 standards for drinking water is 0.05mg per liter. Then, chromium III is nutritionally essential, non toxic and poorly absorbed. Chromium IV is much more toxic than chromium III, causes liver and kidney damage, internal hemorrhaging, respiratory damage, dermatitis and ulcers of the skin at high concentrations.

The longtime consumption of drinking water with high concentration of the heavy metals stated above can lead to problem or little trace of it might also have an effect.

2.5 Treatment Methods for Heavy Metals (Zn, Mn, Cr) Removal

There are number of technology available for the removal of heavy metals. Chemical precipitation is most commonly employed for most of the metals. Common precipitations include OH^-, CO_3^{2-} and S^{2-}. Metals are precipitated as the hydroxide through the addition of lime amphoteric and exhibit a point of minimum solubility. The pH of minimum solubility varies with the metal in question. Metals can also be precipitated as the sulphide or in some cases as the carbonate. With precipitation and classification alone, effluent metal concentrations may be as high as 1 to 2mg per liter. Filteration could reduce these concentrations to 0.5mg per liter or less.

Metals can be removed by absorption or activated carbon, aluminium oxides, silica, clays and synthetic material such as Zeolites and resins. In the case of absorption, higher pH favors the absorption of cation while a lower pH favors the absorption of anion.

2.5.1 Removal of Manganese

Among the many forms and compounds of manganese only the manganous salts and the highly oxidized permanganate anion are appreciably soluble. The latter is a strong oxidant that is reduced under normal circumstances to insoluble manganese dioxide. The treatment techniques for its removal conversion of the soluble manganous ion to an insoluble precipitate. Removal is effected with oxidation of the manganous ion and separation of the resulting insoluble oxides and hydroxides. Manganous ion has a low reactivity with oxygen and simple aeration is not an effective technique below pH 9 (Alkaline). It has been reported that even at high pH levels, organic matter in solution can combine with manganese reduction by precipitation. The use of chemical oxidants to convert manganous ion to insoluble manganese dioxide in conjunction with coagulation and filtration has been employed.

2.5.2 Removal of Zinc

Zinc can be removed by precipitation as zinc hydroxide with either lime or caustic. The disadvantage of lime addition is the concurrent precipitation of calcium sulphate in the presence of high sulphate level in the water.

2.5.3 Removal of Chromium

The reducing agent commonly used for chromium wastes are ferrous sulphate, sodium meta-bisulphate, or sulphur dioxide. Ferrous sulphate and sodium meta-bisulphate may be dry or solution-fed, SO_2 is diffused into the system directly fromm gas cylinder. Since the reduction of chromium is most effective at acidic pH values, a reducing agent with acidic properties is desirable.

These heavy metal removal systems have the following disadvantages:

- They often require the use and handling of strong oxidants,
- they do not always produce a satisfactory effluent quality, and
- the filtration rates are limited; thereby making the equipment large and expensive (Samaila, 2004).

3 MATERIALS AND METHOD

3.1 Study Area

The study area, Kpakungu, is situated in South-West geographical zone of Minna, Niger state. It lies between longitude 6° 31′E - 6° 32′E and latitude 9° 35′N - 9° 36′N. Kpankungu falls within the Middle Belt of Nigeria (Southern Guinea Savanna). It has an average annual rainfall ranging between 1200mm and 1300mm, in August rainfall is at its peak. The range of temperature; varies from 19.73°C-37.32°C and the climate has excess humidity during greater part of the year. The months of February, March and April of every year, the area is at its peak of hotness, during this period the people of that area depends on underground water to sustain their life.

The dump sites are located close to the residential structures in Kpakungu, while pit latrines are inside the compounds and very close to the well about 1 m away. Also, gutters are close to these wells. The wells studied are within this radius, these wells are very close to either the dump or latrine or gutters that the leachate definitely impacts on the ground water overtime (Plates 1 to 3).


Plate 4.1 Refuse dump site close to an open well


Plate 4.2 Affected well close to a residential toilet


Plate 4.3 Affected well close to a household canal

4 RESULTS AND DISCUSSION

4.1 Discussion of Results

Table 4.1 shows that most of the tested physical parameters (except odour) were found not to be within the acceptable limits as recommended by WHO-GLV. However, most of the chemical parameters were found to be within the acceptable limits except for Iron (Fe) in sample 1 which was relatively too high.

Chemical characteristics, positive variance in pH and biological characteristics of the samples tested and recorded. The total coli form count (indication of faecal contamination) and E.coli are high for all the samples from the well. The wells are 2m, 120m, 150m away from the dump site i.e. the biological characteristic is far above the WHO and Nigeria Industrial Standard (NIS). Therefore, based on these results the groundwater from such shallow well aquifers shows a significant level of contamination and therefore not safe for human consumption, because its implication on health. However, it can only used for domestic purposes such bathing, washing and raising of plants in the garden.

Table 4.1: Results of physio-chemical analyses

Parameter	Unit	Sample No. 1	2	3	WHO GLV (2007)	NIS 554:2007 (Permitted Max. Level)
Temperature	^0C	28.8	28.7	28.6	25	Ambient
pH	-	6.81	6.96	6.45	6.5-8.5	6.5-8.5
Conductivity	µs/cm	1039	1362	1075	10-1000	10-1000
Colour	TCU	337	371	324	15	15
TDS	Mg/L	696.13	912.54	720.25	1000	500
Turbidity	NTU	16.13	2.24	5.44	5	5
Dissolved Oxygen	mg/l	4.68	5.55	4.77	7.5	-
Suspended solid	mg/l	14	0	0	-	-
Fluoride	mg/l	0.01	0.49	0.22	1.5	1
Chloride	mg/l	150.95	143.45	145.95	250	250
Total hardness	mg/l	150	193	153	100	150
Cal Hardness	mg/l	125	121	122	-	150
Mg Hardness	mg/l	25	72	31	-	-
Ca^{2+}	mg/l	50.1	48.49	48.89	-	-
Chromium	mg/l	0.00043	0.00043	0.00014	0.05	0.05
Magnesium	mg/l	6.1	17.56	7.56	-	-
Alkalinity	mg/l	121	293	104	200	-
CO_3^-	mg/l	0	0	0	-	-
Sodium	mg/l	75.04	61.5	59	200	200
Potassium	mg/l	23.45	65.66	22.78	-	-
Ammonia	mg/l	1.8	1.3	2.6	-	-
$HCO3^-$)	mg/l	121	293	104	-	-
Manganese	mg/l	0.022	0.07	0.106	0.2	0.05
Iron	mg/l	0.85	0.08	0.13	0.3	0.3
Zinc	mg/l	0.04	0.07	0.11	3	5
Nitrate	mg/l	7.97	5.75	11.51	50	10
Hydroxide	mg/l	0	0	0	-	-
Total coliform	cfu/ml	204	160	75	0	10
E-coli	cfu/100 ml	4	3	15	0	0

Source: Regional Water Quality Laboratory Minna (Dec. 2009)

5 CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

The study of this area has revealed that the concentration of waste materials from pit latrines, wastewater canals very close or within the residential households often influence groundwater pollution and subsequent contamination over a given period.

Obviously, the problems associated with environmental pollution have negative tendencies on the quality of life of the people within the radius of such affect community.

It is found that the water is polluted both physically and biologically. Pollution of the wells depends on the nature of the well i.e. its nearness to domestic wastes, depth of the well, fetching technique, well-cover and droppings (organic and inorganic wastes) into the well.

5.2 Recommendations

a. Land disposal is the most common management strategy for municipal solid waste;

b. Refuse can be safely deposited in a sanitary land fill a disposal site that is carefully selected, designed, constructed and operated to protect the environment and public health;

c. The government should enforce the monthly environmental sanitation;

d. Strict measures should be taken against environmental ethics violation;

e. The society should be adequately enlightened about ecological apathy;

f. The sides of the well should be lined with impervious material to a depth of about three meters to prevent the entering of the water flowing near the ground;

g. An area within 15 meters of the well should be kept free from pollution. In this area, there should be no any pit latrines, soak a ways or cesspits should be relocated and refuse dump should be minimum of 200 meters away; and

h. Local government should designate area where all forms of waste are to be dumped. License should be issued and renewed for permission to dump waste in the specified area.

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