Open Access Journal of Chemistry
Volume 2, Issue 4, 2018, PP 11-20
ISSN 2637-5834

Heavy Metals and Bacteriological Analyses of Water Samples from Hand-Dug Wells in Lafia Metropolis

Abel Uche Augustine[1*], Godwin Attah Obande[2], Osuagwu Onyeberechiya Stanislaus[1], Akinbinu Blessing Bosede[1]

[1]Department of Chemistry, Federal University Lafia-Nigeria
[2]Department of Microbiology, Federal University Lafia-Nigeria

***Corresponding Author:** Abel Uche Augustine, Department of Chemistry, Federal University Lafia-Nigeria. abelloves@yahoo.com*

ABSTRACT

People on earth are under tremendous threat due to undesired changes in the physical, chemical and biological characteristics of air, water and soil. Due to increased human population, industrialization, agricultural and other man-made activities in Lafia, water bodies, especially hand-dug wells are highly polluted with different harmful contaminants. This study investigated the bacteriological quality and heavy metals from water in hand-dug wells in Lafia metropolis of Nasarawa State. A total of five selected hand-dug well samples were analyzed using standard methods. The concentration of heavy metals, ranged as follows: lead (0.559 – 0.65485 mg/L), iron (0.061 – 0.383 85 mg/L), and chromium (0.112 – 0.178 mg/L). The concentrations of the heavy metals studied were all higher than the WHO standard except for samples 1, 2, 3, and 4 which had iron concentration that were below the standard. Bacteriological analysis carried out on the water showed that none of the samples complied with bacteriological standards as total aerobic counts, generally exceeded permissible limit of 100 CFU/ml for coliform count and 1.0 x 102 CFU/ml for bacteria and pathogenic bacteria such as Escherichia coli, Pseudomonas aerugenosa, Staphylococcus aureus, Staphylococcus spp, Serretia marcescens, Proteus spp, Micrococcus spp were isolated.

Keywords: *Water, Bacteria, Heavy Metals, Analysis, Lafia*

INTRODUCTION

The quality of water is important in environmental studies because of its daily use for human consumption and its ability to transport pollutants. Water is obtained from a number of sources, some of which are rain, lakes, streams, underground wells, and springs. A major source of water in both rural and urban areas is groundwater (Gupta *et al.*, 2009). In Lafia town, groundwater is the most important source of supply for domestic, drinking and other purposes. Increase in water usage due to increasing population has led to the deterioration of sub-surface water (Saravanakumar and Kumar, 2011). A large percentage of the populace in developing countries die annually due to water borne diseases such as cholera, typhoid, diarrhea, etc. (WHO, 2008).

The quality of ground water depends on various chemical constituents and their concentration, which are mostly derived from the geological data of the particular region. Industrial waste and the municipal solid waste have emerged as one of the leading cause of pollution of surface and ground water. In many parts of the country available water is rendered non-portable because of the presence of heavy metals in excess. The situation gets worsened during the summer season due to water scarcity and rain water discharge. Contamination of water resources available for household and drinking purposes with heavy elements, metal ions and harmful microorganisms is one of the serious major health problems. A recent research in Haryana (India) concluded that it is the high rate of exploration than its recharging, inappropriate dumping of solid and liquid wastes, lack of strict enforcement of law and loose governance are responsible for deterioration of ground water quality (Gupta, 2009).

Groundwater through hand-dug wells can be contaminated by soil particles eroded during heavy downpours on which water impairing substances like nitrates and phosphates are washed into the wells (Taiwo *et al.*, 2011).

Most of the underground wells in Lafia are exposed to the air thereby making them prone to contamination from environmental waste and particulate matters in the air. There is a need to

look for some useful indicators, both physical and chemical which can be used to monitor Lafia underground well water for drinking and domestic purposes. The result of this study will provide a baseline data for future water quality monitoring in Lafia.

Over the last few years, surface water and groundwater resources are among the most important environmental issues due to heavy metals contamination and human industrial activities (Marcovecchio *et al*., 2007; Ozturk *et al*., 2009; Kwakye-Nuako *et al*., 2011; Ghasemi *et al*., 2011). Heavy metal contamination has become a significant problem in several communities, mining and agricultural areas over the years due to the use of commercial agrochemicals in agricultural production (Rattan *et al*., 2005)

A principal microbiological concern in groundwater is the health hazard posed by faecal contamination. Of the four types of pathogens (viruses, bacteria, protozoa, and parasite) contained in human excreta, only bacteria and viruses are likely to be small enough to be transmitted through the soul and aquifer matrix to groundwater bodies (Agunwamba, 2001).

Contaminants such as bacteria, viruses, heavy metals, nitrates and salt have polluted water supplies as a result of inadequate treatment and disposal of waste from humans and livestock, industrial discharges, and over-use of limited water resources (Singh and Mosley, 2003). Even if no sources of anthropogenic contamination exist, there is potential for natural levels of metals and other chemicals to be harmful to human health. This was highlighted in Bangladesh where natural levels of arsenic in groundwater were found to be causing harmful effects on the population (Apau *et al*., 2014). The presence of *Escherichia coli* in drinking water denotes that the water has a contamination and therefore presents a potential health risk to households that use them untreated. There is continuous contamination of hand-dug well waters used for drinking and other domestic purposes in Lafia by bacteria and heavy metals. Therefore, there is need to investigate the presence of bacterial and heavy metals such as iron (Fe), chromium (Cr), and lead (Pb) contents of hand-dug well waters in Lafia metropolis.

Materials And Methods

Description of the Study Area

Lafia city is the capital of Nasarawa state and one of the thirteen (13) local government areas of the state. It has a tropical climate with an average annual temperature and rainfall of 34.2^{o}C and 108 mm respectively. The highest precipitation occurs in August with an average of 344.8 mm. The highest average temperature of 38^{o}C occur between March and April. The minimum average temperature of about 19.3^{o}C occurs in December. The variation in temperature throughout year is 5.9^{o}C (NEITI, 2013).

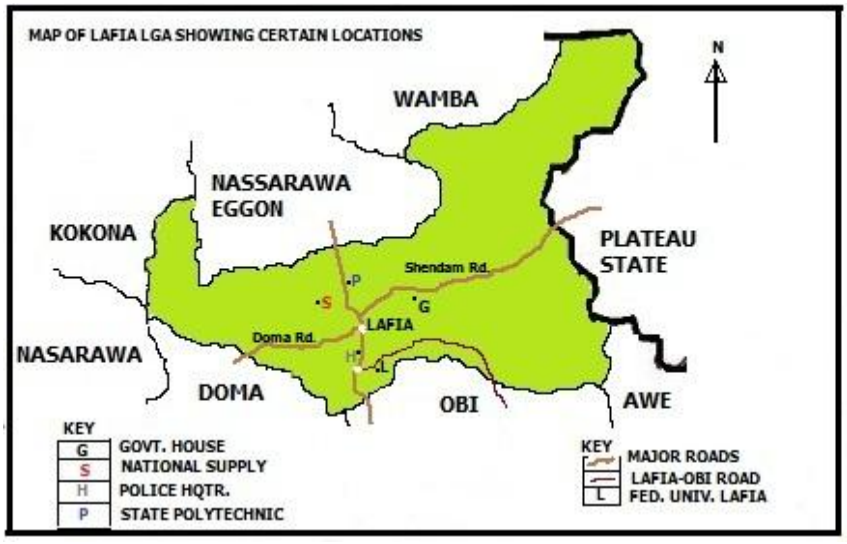

Fig1. *Map of Lafia including Sampling areas*

Sample Collection

Water from hand-dug wells in Lafia city were collected in April 2016 from five (5) different locations along each of these routes: Tudun Kauri-Makurdi Road, Shendam road, National supply-Jos Road, Nasarawa State polytechnic, Lafia and Mararaba Akunza-Obi Road. The activities carried out within the vicinity of the various sampling points were noted. Samples were collected using hard plastic and screw-capped bottles that have been sterilized to avoid

contamination by any physical, chemical or microbial means, after the water was agitated. The samples were filtered and acidified with nitric acid (HNO_3) to a pH < 2. All the samples were collected in duplicates and were designated as well one (W_1), well two (W_2), well three (W_3), well four (W_4) and well five (W_5) respectively.

Determination of Total Metal Levels in Water

A 100 mL of the water sample was placed in a 125 mL conical flask and digested with 5 mL of concentrated nitric acid, HNO_3 on a hot plate at 95 ^oC until a clear solution was obtained. The wall of the conical flask was washed down with deionized water and then filtered. The filtrate was then transferred into a 100 mL volumetric flask, diluted to mark with deionized water and mixed thoroughly. The total metals concentration of iron , lead and chromium were determined using an atomic absorption spectrometer (AAS) (APHA, 1999).

Bacteriological Analysis

A ten-fold serial dilution was performed on all samples collected using sterile distilled water as blank. Nine (9.0) mL of sterile distilled water was dispensed into ten clean test tubes. One (1.0) mL of the sample was aseptically transferred into the first tube and thoroughly mixed together. One (1.0) mL was drawn from the first tube into the second tube and thoroughly mixed together. The process was continued up to the tenth test tube. One-tenth of a milliliter was drawn from the sixth dilution and inoculated on culture media using the spread plate technique (Gupta, 2013).

Enumeration of bacterial contaminants

The total viable count and total coliform counts were determined on Nutrient agar and MacConkey agar respectively. One-tenth of a milliliter from the serially diluted samples were each aseptically transferred to the surface of sterile Nutrient and MacConkey agar plate and spread out using a sterilized spreader. The inoculated plates were allowed to stand on the bench for a while for the medium to absorb the inoculum, after which they were incubated at 37 ^oC for 24 hours. The numbers of colonies were counted and the colony forming unit (CFU) per milliliter of water was determined using the formula as reported by Gupta (2013):

CFU/ml = no. of colonies/inoculums size (ml) x reciprocal of dilution factor

Isolation of contaminants

Isolation of Escherichia coli

Eosin methylene blue agar and MacConkey agar were used for the isolation of *Escherichia coli*. A loopful of the stock preparation was streaked on both media and incubated at 35 – 37 ^oC for 18 - 24 hours. Colonies with greenish metallic sheen on eosin methylene blue agar and lactose fermenters on MacConkey agar were suspected to be *Escherichia coli* and were selected for further identification (Gupta, 2013).

Isolation of Salmonella Spp

Salmonella-Shigella agar was used for the isolation of *Salmonella* spp and *Shigella*spp, with pre-enrichment in Rappaport-Vassiliadis (RV) Enrichment Broth. Three (3) loopfulls of the stock preparation was inoculated into Rappaport-Vassiliadis (RV) Enrichment Broth prepared in screw capped bottles according to the manufacturer's instructions.

The broth was, thereafter, incubated for 48 hours after which it was mixed and two loopfulls were streaked on the surface of salmonella-shigella agar. The plate was then incubated at 37^oC for 24 hours. Colourless colonies with dark spots were suspected to be *Salmonella* spp and thus, selected for further identification (Gupta, 2013).

Isolation and Identification of other Contaminants

Other bacterial contaminants were isolated from the nutrient agar plates used for determination of the viable counts and the other selective media used in the study. Discrete colonies with similar morphological characteristics were selected from the media on which they grew for identification. Colonies were first sub-cultured on both nutrient agar and the other selective media, and discrete colonies obtained were used for identification tests (Gupta, 2013).

Identification of isolates

Microscopic Identification

Gram stain

A small portion of 18 - 24 hours old colony was emulsified in a drop of sterile normal saline on a clean glass slide and fixed by passing the smeared slide rapidly over flame. The smear was covered with crystal violet for about 30 seconds, rinsed with water and flooded with iodine for 30 seconds. The smear was then rinsed, rapidly decolorized with acetone and counter-stained with safaranine for about 30

seconds. After air drying, the slide was viewed using the oil immersion (100×) objective, under a light microscope. Purple cells were noted as Gram-positive, while reddish cells were noted as Gram-negative (Gupta, 2013).

Biochemical Test

Catalase Test

Using a sterile syringe, 2 – 3 drops of hydrogen peroxide was placed on a clean glass slide. A small portion of the test organism was added to the hydrogen peroxide on the slide. Observation of active bubbling was noted as a positive reaction while the absence of bubbles was noted as negative reaction (Abdulkadir and Waliyu, 2012; Cowan and Steel, 1993).

Methyl Red Test

Inoculated MR-VP broth was incubated for 48-72 hours at 37 °C after which, one milliliter (1 ml) of the broth was transferred into a small tube. Few drops (2-3 drops) of methyl red were added to it. Color change of the medium provides the result. A red color shows MR positive bacterium while a yellow color shows an MR negative bacterium (Abdulkadir and Waliyu, 2012; Cowan and Steel, 1993).

Urease Test

The urease test identifies those organisms that are capable of hydrolyzing urea to produce ammonia and carbon dioxide.

$$(NH_2)_2\ CO + H_2O \rightarrow\ CO_2 + 2NH_3$$

Urease test media contain 2 % urea and phenol red as a pH indicator. Urease slant was streaked with the test organism and incubated at 35^{o}C with daily observation. An increase in pH due to the production of ammonia results in a color change from yellow to bright pink indicative of a positive result (Cowan and Steel, 1993).

Indole Test

This test shows the breaking down of the amino acid tryptophan with the release of indole. A portion of the test organism was inoculated into motility indole urease agar (MIU) prepared according to manufacturer's instruction. The culture was then incubated for 48 hours, after which Indole Kovac's reagent was added. Appearance of a red ring on the surface of the culture in the test tube was indicative of a positive reaction while the absence of it was considered a negative reaction (Abdulkadir and Waliyu, 2012; Cowan and Steel, 1993).

Motility Test

This was carried out using the motility indole urease (MIU) agar which was prepared according to the manufacturer instruction. A portion of the test organism was picked with a loop and stabbed into the medium. The tube was incubated for 18 to24 hours at 37^{o}C. Cloudiness of the medium indicated a positive result (Abdulkadir and Waliyu, 2012; Cowan and Steel, 1993).

Citrate Test

Was performed to determine the ability of the isolate to use citrate and the Simmon citrate agar was used. Slants of the agar were prepared in sterile screw capped bottles and the slants were inoculated with the test organism. The resulting culture was incubated overnight. A deep blue colour was an indication that the organism used citrate as a carbon source while a green colour indicated otherwise (Abdulkadir and Waliyu, 2012; Cowan and Steel, 1993).

Coagulase Test

A suspension of the test organism was made in a drop of sterile normal saline on a slide from an 18 - 24 hours old culture. A drop of plasma was thereafter, added to the suspension and mixed. Clumping of the test organism within 10 seconds implied a positive result. The absence of clumping after 10 seconds indicated a negative result (Cowan and Steel, 1993).

Oxidase Test

This was carried out using Microbact Oxidase strips. A portion of the test organism was rubbed on the surface of the strip and observed after about 10 seconds. A deep blue colour showed a positive result while the absence of a deep blue colour or a delay in its appearance indicated a negative result (Abdulkadir and Waliyu, 2012; Cowan and Steel, 1993).

Sugar Fermentation Test

This was conducted using the Triple Sugar Iron agar (TSI) which is made up of glucose, lactose and sucrose. Slants of the medium were prepared in test tubes. A portion of the test organism was streaked along the slope and the butt was stabbed through to the bottom. The tube was then incubated for 18 - 48 hours and the result read. A yellow color implied that sugar was fermented.

The appearance of air spaces within the medium in the test tube showed gas formation (Abdulkadir and Waliyu, 2012; Cowan and Steel, 1993).

Results And Discussion

Lead (Pb)

Lead in drinking water is primarily from the corrosion of the lead used to put together the copper piping. Lead in the body can cause

serious damage to the brain, kidneys, nervous system and red blood cells (Hertz-Picciotto, 2000). Exposure to lead is of special concern among women particularly during pregnancy. Lead absorbed by the pregnant mother is readily transferred to the developing fetus (Yedjou *et al*., 2006). Human evidence corroborates animal findings, linking prenatal exposure to lead with reduced birth weight and preterm delivery, and with neuro-developmental abnormalities in offspring (Yedjou *et al*., 2006). Lead results obtained ranged from 0.559 – 0.654 mg/L with mean value of 0.6046 mg/L. Well (W) 1,2,3,4 and 5 are all above the WHO standard level of 0.01 mg/L for drinking water as shown in Fig 3.1 when compared and which makes the water unfit for consumption.

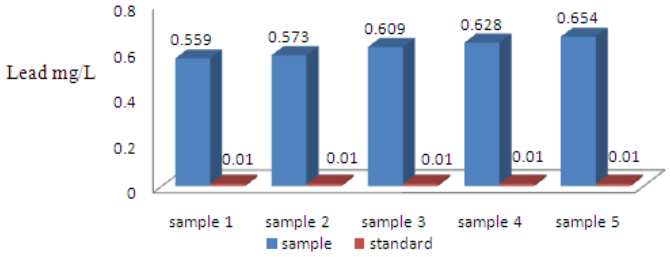

Fig2. *Comparison of Lead concentration Levels with Standard*

Iron (Fe)

The results of iron obtained ranged from 0.383 – 0.061 mg/L. Sample 1, 2, 3, and 4 were within the WHO standard, while sample 5 was not within the WHO standard of 0.3 mg/L as shown in Fig 3.2. Iron forms rust-coloured sediment, stains laundry, utensils, and so on. Iron is objectionable for food and beverage processing (Arruti *et al*., 2010). It can promote growth of certain kinds of bacteria that clog pipes and well openings and also reddening of teeth. The toxicity of iron on cells has led to iron mediated tissue damage involving cellular oxidizing and reducing mechanisms and their toxicity towards intracellular organelles such as mitochondria and lysosomes (Arruti *et al*., 2010). A wide range of free radicals that are believed to cause potential cellular damage are produced by excess intake of iron. The iron produced hydrogen free radicals attack DNA, resulting in cellular damage, mutation and malignant transformations which in turn cause an array of diseases (Grazuleviciene *et al*., 2009).

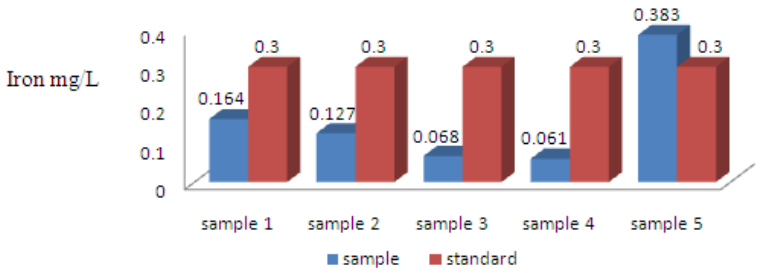

Fig3. *Comparison of Iron Concentration Levels with WHO Standard*

Chromium (Cr)

Occupational and environmental exposure to Cr (VI) containing compounds is known to cause multiorgan toxicity such as renal damage, allergy and asthma, and cancer of the respiratory tract in humans (Goyer, 2001). The results of chromium ranged from 0.178 – 0.112 mg/L and the entire samples were above the WHO standard of 2007 (0.1 mg/L) as shown in Fig 3.3 when compared.

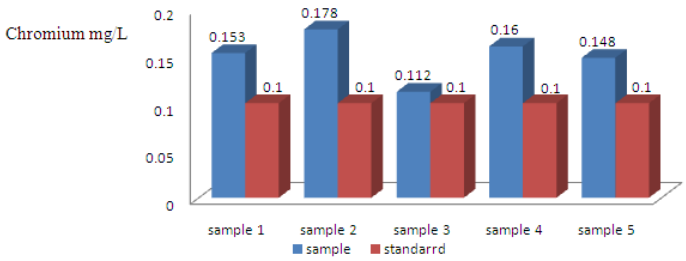

Fig4. *Comparison of Chromium Concentration Levels with WHO Standard*

Bacteriological Analysis

Table3.1. *Total Aerobic Count of Water Samples*

SAMPLE	TOTAL AEROBIC COUNT ($x10^6$cfu/ml)
W_1^A	TNTC
W_1^B	TNTC
W_2^A	TNTC
W_2^B	TNTC
W_3^A	TNTC
W_3^B	TNTC
W_4^A	TNTC
W_4^B	TNTC
W_5^A	TNTC
W_5^B	TNTC

Results of the bacteriological analysis of the water sample are as presented in Table 3.1 The total aerobic counts for all water samples were all in a range of Too Numerous To Count (TNTC).

Total aerobic count (TAC) measures a range of bacteria that are naturally present in the environment (EPA, 2002). The total bacterial counts for all the water samples were generally high, exceeding the limit of 1.0 x 10^2cfu/ml which is the standard limit of total aerobic count for drinking water (EPA, 2002). The high total aerobic bacterial count is indicative of the presence of high organic and dissolved salts in the water. The primary sources of these bacteria in water are animal and human wastes. These sources of bacterial contamination include surface runoff, pasture, and other land areas where animal wastes are deposited. Additional sources include seepage or discharge from septic tanks, sewage treatment facilities and natural soil or plant bacteria (EPA, 2002). Furthermore, human activities and practices by users of the wells could have contributed to the high counts recorded in the respective samples. It was observed that most of the wells were without cover and were built in such a way that users stood on the surface to collect water. This practice washes dirt and other extraneous materials from the users into the wells which lead to contamination of the water. It was also observed at the water sources that most of the wells had no designated fetchers. Instead, different containers were used to collect water from inside the well. This could have introduced bacteria from different sources into the water.

Table3.2. *Bacterial contaminants isolated from hand dug wells*

S.No	Sample	Isolated organism
1	W_1^A	*Staphylococcus aureus*
2	W_1^B	*Micrococcus spp*
3	W_2^A	*Staphylococcus spp*
4	W_2^B	*Staphylococcus aureus*
5	W_3^A	*Staphylococcus aureus*
6	W_3^B	*Staphylococcus aureus*
7	W_4^A	*Escherichia coli*
8	W_4^B	*Pseudomonas aeruginosa*
9	W_5^A	*Serretia marcescens*
10	W_5^B	*Proteus spp*

WA and WB represent the first and second samples collected; W1 –W5 represent sample numbers; + = positive; - = negative

The bacteria isolated from water samples in this study include *Escherichia coli*, *Pseudomonas aeruginosa*, *Staphylococcus aureus*, *Staphylococcus* spp, *Serretia marcescens*, *Proteus* spp and *Micrococcus* spp. Most bacterial pathogens potentially transmitted by water infect the gastrointestinal tract and are excreted in the faeces of infected humans and animals. However, there are also some waterborne bacterial pathogens, such as *Legionella*, *Burkholderia pseudomallei* and atypical mycobacteria, which can grow in water and soil. The routes of transmission of these bacteria include inhalation and contact (bathing), with infections occurring in the respiratory tract, in skin lesions or in the brain (WHO, 2011). *Escherichia coli* are present in large numbers in the normal intestinal flora of humans and animals, where it generally causes no harm. However, in other parts of the body, *E. coli* can cause serious disease, such as urinary tract infections, bacteraemia and meningitis. A

limited number of enteropathogenic strains can cause acute diarrhea (WHO, 2011). EHEC serotypes, such as *E. coli* O157:H7 and *E. coli* O111, cause diarrhoea that ranges from mild and non-bloody to highly bloody, which is indistinguishable from haemorrhagic colitis. Between 2% and 7% of cases can develop the potentially fatal haemolytic uraemic syndrome, which is characterized by acute renal failure and haemolytic anaemia. Children under 5 years of age are at most risk of developing haemolytic uraemic syndrome (WHO, 2011).

Enteropathogenic *E. coli* are enteric organisms, and humans are the major reservoir, particularly of EPEC, ETEC and EIEC strains. Livestock, such as cattle and sheep and, to a lesser extent, goats, pigs and chickens, are a major source of EHEC strains. The latter have also been associated with raw vegetables, such as bean sprouts. The pathogens have been detected in a variety of water environments (WHO, 2011).

Pseudomonas aeruginosa can cause a range of infections but rarely causes serious illness in healthy individuals without some predisposing factor. It predominantly colonizes damaged sites such as burn and surgical wounds, the respiratory tract of people with underlying disease and physically damaged eyes. From these sites, it may invade the body, causing destructive lesions or septicaemia and meningitis. Cystic fibrosis patients and immunocompromised patients are prone to colonization with *P. aeruginosa*, which may lead to serious progressive pulmonary infections. Water-related folliculitis and ear infections are associated with warm, moist environments such as swimming pools and spas. Many strains are resistant to a range of antimicrobial agents, which can increase the significance of the organism in hospital settings (WHO, 2011). *Pseudomonas aeruginosa* is a common environmental organism and can be found in faeces, soil, water and sewage. It can multiply in water environments and also on the surface of suitable organic materials in contact with water.

Pseudomonas aeruginosa is a recognized cause of hospital-acquired infections with potentially serious complications. It has been isolated from a range of moist environments such as sinks, water baths, hot water systems, showers and spa pools (WHO, 2011).

Staphylococcus aureus is an aerobic or anaerobic, non-spore forming, catalase negative and coagulase positive, Gram positive coccus, usually arranged in grape-like, irregular clusters. The genus Staphylococcus contains at least 15 different species. Apart from *S. aureus*, the species *S. epidermidis* and *S. saprophyticus* are also associated with disease in humans. Although *Staphylococcus aureus* is a common member of the human micro-flora. It can produce disease through two different mechanisms. One is based on the ability of the organisms to multiply and spread widely in tissues, and the other is based on the ability of the organisms to produce extracellular enzymes and toxins. Infections based on the multiplication of the organism are a significant problem in hospitals and other health-care facilities. Multiplication in tissues can result in manifestations such as boils, skin sepsis, post-operative wound infections, enteric infections, septicaemia, endocarditis, osteomyelitis and pneumonia. The onset of clinical symptoms for these infections is relatively long, usually several days. Gastrointestinal disease (enterocolitis or food poisoning) is caused by a heat-stable staphylococcal enterotoxin and characterized by projectile vomiting, diarrhoea, fever, abdominal cramps, electrolyte imbalance and loss of fluids. Onset of disease in this case has a characteristic short incubation period of 1–8 hours. The same applies to the toxic shock syndrome caused by toxic shock syndrome toxin-1 (WHO, 2011).

Staphylococcus aureus is relatively widespread in the environment but is found mainly on the skin and mucous membranes of animals. The organism is a member of the normal microbial flora of the human skin and is found in the nasopharynx of 20–30% of adults at any one time. Staphylococci are occasionally detected in the gastrointestinal tract and can be detected in sewage. *Staphylococcus aureus* can be released by human contact into water environments such as swimming pools, spa pools and other recreational waters. It has also been detected in drinking-water supplies (WHO, 2011).

Micrococci have been isolated from human skin, animal and dairy products, and beer. They are found in many other places in the environment, including water, dust, and soil. *M. luteus* on human skin transforms compounds in sweat into compounds with an unpleasant odour. Micrococci can grow well in environments with little water or high salt concentrations. Most are mesophiles; some, like *Micrococcus antarcticus* (found in Antarctica) are psychrophiles. Though not a spore former, Micrococcus cells can survive for an extended period of time, both at refrigeration temperatures, and in nutrient-poor conditions such as being sealed in amber

(Greenblat, *et al.*, 2004). It can be difficult to identify Micrococcus as the cause of an infection. Since the organism is normally present in skin microflora, and the genus is seldom linked to disease. In rare cases, death of immune compromised patients has occurred from pulmonary infections caused by Micrococcus.

Micrococci may be involved in other infections, including recurrent bacteremia, septic shock, septic arthritis, endocarditis, meningitis, and cavitating pneumonia (immuno suppressed patients) (Greenblat *et al.*, 2004). Micrococci, like many other representatives of the Actinobacteria, can be catabolically versatile, with the ability to utilize a wide range of unusual substrates, such as pyridine, herbicides, chlorinated biphenyls, and oil (Doddamani, *et al.*, 2001).

They are likely involved in detoxification or biodegradation of many other environmental pollutants. Other Micrococcus isolates produce various useful products, such as long-chain (C21-C34) aliphatic hydrocarbons for lubricating oils (Zhuang, *et al.*, 2003).

S. marcescens is a human pathogen involved in hospital-acquired infections (HAIs), particularly catheter-associated bacteremia, urinary tract infections and wound infections (Auwaerter, 2007), and is responsible for 1.4% of HAI cases in the United States. It is commonly found in the respiratory and urinary tracts of hospitalized adults and in the gastrointestinal system of children.

Due to its abundant presence in the environment, and its preference for damp conditions, *S. marcescens* is commonly found growing in bathrooms (especially on tile grout, shower corners, toilet water line, and basin), where it manifests as a pink, pink-orange, or orange discoloration and slimy film feeding off phosphorus-containing materials or fatty substances such as soap and shampoo residue. *S. marcescens* may also be found in environments such as dirt, supposedly "sterile" places, and the subgingival biofilm of the teeth.

Due to this, and because *S. marcescens* produces a reddish-orange tripyrrole pigment called prodigiosin, it may cause staining of the teeth.

The biochemical pathway for the production of prodigiosin by *S. marcescens* is unknown except for the final two steps. In these steps, a monopyrrole and a bipyrrole undergo a condensation reaction by way of an enzyme to form prodigiosin.

Once established, complete eradication of the organism is often difficult, but can be accomplished by application of a bleach-based disinfectant. Rinsing and drying surfaces after use can also prevent the establishment of the bacterium by removing its food source and making the environment less hospitable (Auwaerter, 2007). In humans, *S. marcescens* can cause infection in several sites, including the urinary tract, respiratory tract, wounds, and the eye, where it may cause conjunctivitis, keratitis, endophthalmitis, and tear duct infections (Patterson, *et al.*, 2002).

It is also a rare cause of endocarditis, pneumonia, and meningitis and osteomyelitis (particularly in people who use intravenous drugs recreationally), (Auwaerter, 2007). Most *S. marcescens* strains are resistant to several antibiotics because of the presence of R-factors, which are a type of plasmid that carry one or more genes that encode resistance; all are considered intrinsically resistant to ampicillin, macrolides, and first-generation cephalosporins (such as cephalexin) (Auwaerter, 2007).

P. mirabilis causes 90 % of all Proteus infections in humans. It is widely distributed in soil and water (Ryan, et al., 2004). This rod-shaped bacterium has the ability to produce high levels of urease, which hydrolyzes urea to ammonia (NH_3) and makes the urine more alkaline. If left untreated, the increased alkalinity can lead to the formation of crystals of struvite, calcium carbonate, and/or apatite, which can result in kidney stones.

The bacteria can be found throughout the stones, and these bacteria lurking in the kidney stones can reinitiate infection after antibiotic treatment. Once the stones develop, over time they may grow large enough to cause obstruction and renal failure. *Proteus* species can also cause wound infections, septicaemia, and pneumonia, mostly in hospitalized patients (Matsuyama *et al.*, 2000).

CONCLUSION

This study showed that bacteriological and heavy metal contamination in water from hand - dug wells in Lafia metropolis contain high concentrations of pollutants. These can be attributed to run-off water, well located close to septic tanks, receptacles and ropes and contaminated rain water that enter into the hand dug wells. However, the results indicate dangerous health implications to both human and animals that use water from this source. As a result of the high concentrations of

bacteriological and heavy metal contamination of water from the hand dug wells, health problem such as typhoid fever, cholera, diarrhea, worm infestation and gastro-intestinal water borne diseases are imminent with continued use of such water without adequate decontamination.

REFERENCES

[1] Abdulkadir, I and Waliyu, O. (2012). Screening and Isolation of the Soil Bacteria for Ability to Produce Antibiotics, *European Journal of Applied Sciences*, 4 (5): 211-215.

[2] Agunwamba, J. C (2001). Waste Engineering & Management Tools. Immaculate publications limited, I Enugu.

[3] Apau, J., Acheampong, A. and Bepule, V. (2014). Physicochemical and microbial parameters of water from hand-dug wells from Nyamebekyere, a surburb of Obuasi, Ghana. *Int J Sci.Technol.*, 3(6):347–351.

[4] APHA. (1999). Standard Method for Examination of Water and Wastewater, 18th edn. American Public Health Association, Washington D. C.

[5] Arruti, A., Fernandez-Olmo, I., Irabien, A.(2010). Evaluation of the contribution of local sources to trace metals levels in urban PM 2.5 and PM 10 in the Cantabria region (Northern Spain). *J Environ Monit*., 12(7):1451–1458.

[6] Auwaerter, P. (2007). "Serratia species". Point-of-Care Information Technology ABX Guide. Johns Hopkins University. Retrieved 13 December 2008. Freely available with registration.

[7] Cowan S. T. and Steel. (1993). Manual for Identification of Medical Bacteria. Cambridge University, Cambridge.

[8] Doddamani, H. and Ninnekar, H. (2001). "Biodegradation of carbaryl by a Micrococcus species". *Curr.Microbiol.*, 43 (1): 69–73.

[9] EPA, (2002). US Environmental Protection Agency, Safe Drinking Water Act Ammendment http:// www. epa. gov/safe water /mcl. Html

[10] Ghasemi, M., Keshtkar, A.R., Dabbagh, R. and Jaber, S.S. (2011). Biosorption of uranium in a continuous flow packed bed column using Cystoseiraindica biomass. *Iran J Environ Health Sci. Eng.*, 8:65–74.

[11] Goyer, R.A (2001). Toxic effects of metals. In: Klaassen, CD., editor. Cassarett and Doull's Toxicology. *The Basic Science of Poisons*. New York: McGraw-Hill Publisher, p. 811-867.

[12] Grazuleviciene, R., Nadisauskiene, R., Buinauskiene, J., Grazulevicius, T. (2009). Effects of Elevated Levels of Manganese and Iron in Drinking Water on Birth Outcomes. *Polish J of Environ Stud.*, 18(5): 819–825.

[13] Greenblat, C.L., Baum, J., Klein, B.Y., Nachshon, S., Koltunov, V., and Cano, R.J. (2004). "Micrococcus luteus – Survival in Amber". *Microbial Ecology*, 48 (1): 120–127.

[14] Gupta, D. Sunita, P., and Saharan, J. P. (2009). Physiochemical Analysis of Ground Water of Selected Area of Kaithal City (Haryana) India. *Researcher*, 1(2: 1-5.

[15] Hertz-Picciotto, I. (2000). The evidence that lead increases the risk for spontaneous abortion. *Am J Ind Med.*, 38:300–309.

[16] Kwakye-Nuako, G., Borketey, P.B., Mensah-Attipoe, I., Asmah, R.H. and Kumi, P.F.(2007). Sachet Drinking Water in Accra: The Potential Threats of Transmission of Enteric Pathogenic Protozoan Organisms. *Ghana Med J*., 41(2): 62–7.

[17] Marcovecchio, J.E., Botte, S.E., Freije, R.H. (2007). Heavy metals, major metals, trace elements. In: Nollet LM (ed) *Handbook of water analysis, 2nd edn*. CRC Press, London, pp 275–311.

[18] Matsuyama, T., Takagi, Y., Nakagawa, Y., Itoh, H., Wakita, J. and Matsushita, M. (2000). "Dynamic aspects of the structured cell population in a swarming colony of Proteus mirabilis". *J. Bacteriol*, 182 (2): 385–93.

[19] National Extractive Industries Transparency Initiatives (NEITI)(2013). Report on Revenues, Deductions and Analysis of Disbursement and Utilization of Funds of Selected State Governments 2007 to 2011, Nasarawa State. SIAO partners. pp. 3-5.

[20] Ozturk, M., Ozozen, G., Minareci, O. and Minareci, E. (2009). Determination of heavy metals in fish, water and sediments of Avsar Dam Lake in Turkey. *Iran J Environ Health* Sci *Eng*, 6:73–80.

[21] Patterson, K.L., Porter, J.W. and , K.B.. (2002). "The etiology of white pox, a lethal disease of the Caribbean elkhorn coral, Acroporapalmata". Proc. *Nat.Acad.Sci. USA*, 99 (13): 8725–30.

[22] Rattan, R.K., Datta, S.P., Chhonkar, P.K., Suribabu, K. and Singh, A.K. (2005). Long-term impact of irrigation with sewage effluents on heavy metal content in soils, crops and groundwater: a case study. *Agric Ecosyst Environ*, 109: 310–322.

[23] Ryan KJ; Ray CG, eds. (2004). Sherris Medical Microbiology (4th ed.). McGraw Hill. ISBN 0-8385-8529-9.

[24] Saravanakumar, K. and Ranjith K.R. (2011). Analysis of water quality parameters of ground water near Ambattur Industrial area, Tamil Nadu, India. *India Journal of Science and Technology*. 4(5): 660 – 662.

[25] Singh,I.S. and Mosley, L.M.(2003). Trace metal levels in drinking water on VitiLevu, Fiji Islands. *S Pac J Nat Sci*, 21:3 1–4.

[26] Taiwo, A.M., Adeogun, A.O., Olatunde, K.A. and Adegbite, K.I. (2011). Analysis of Groundwater Quality of Hand-Dug wells in

Peri-Urban Area of Obantoko, Abeokuta, Nigeria for selected Physio-Chemical Parameters. *Pacific Journal of science and Technology*. 12(1):527-534

[27] WHO (2008). Safe water and Global Health. www.who/int/features/qa/70/en/index.htm.

[28] WHO (2011).World Health Organization Guidelines for drinking-water quality, 4thedn. Switzerland, Geneva.

[29] Yedjou, C.G., Steverson, M., Paul, T. P.B. (2006). Lead nitrate-induced oxidative stress in human liver carcinoma (HepG2) cells. *Metal Ions Biol Med*., 9:293–297.

[30] Zhuang W, Tay J, Maszenan A, Krumholz L, Tay S (2003). "Importance of Gram-positive naphthalene-degrading bacteria in oil-contaminated tropical marine sediments". LettApplMicrobiol 36 (4): 251–7.

Citation: *Abel Uche Augustine et al. "Heavy Metals and Bacteriological Analyses of Water Samples from Hand-Dug Wells in Lafia Metropolis". Open Access Journal of Chemistry, 2(4), pp.11-20*