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ASSESSMENT OF SOME MICRONUTRIENTS LEVELS IN DOMESTIC WATER SOURCES IN ESAN, EDO STATE

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ABSTRACT

This study was designed to assess the micronutrients in domestic water sources in Esan land, Edo State, Nigeria, where pipe borne water is rare, and communities rely on alternative sources of water for drinking and domestic purposes. Water samples from boreholes, rivers, and underground rain water reservoirs in the upper and lower plateau of Esan land, were collected to determine the levels of Chromium (Cr), Copper (Cu), Cobalt (Co), Manganese (Mn), Selenium (Se), Iron (Fe), and Zinc (Zn). Samples from Ikogosi Warm spring (IKWS) in Ekiti State, Nigeria, served as control. The results showed that Selenium levels were below detectable limits. Fe was significantly higher for Ekpoma borehole samples (0.48 ± 0.06; $p = 0.00$), followed by river water samples from the upper Esan plateau (0.41 ± 0.03; $p=0.01$). Zn levels in samples from the lower Esan plateau river, was significantly higher (0.43 ± 0.02; $P=0.00$) in comparison with the control. Cobalt was significantly higher for river samples in the lower plateau and upper plateau. Cr, Cu and Mn levels however, were not statistically significant in the study area; suggesting that water from most of these sources in Esan land, would surely be safer if subjected to appropriate water treatment.

Keywords: Water, Micronutrients, Domestic, Esan, Plateau.

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INTRODUCTION

Water is one of the most important substances on earth. All plants and animals must have water to survive (Wolf *et al*., 2013). Water is a transparent fluid which forms the world's streams, Lakes, Ocean and Rain. As a chemical compound, a water molecule contains one oxygen and two hydrogen atoms that are connected by covalent bonds. Water is the major constituent of the fluids of all living things and water is also vital both as a solvent in which many of the body's solutes dissolve and as an essential part of metabolic process within the body (Gleick, 1993). Domestic water (generally known as potable water or improved drinking water) is water safe enough for drinking and food preparation. Globally, in 2012, 89% of people had access to water suitable for drinking. Nearly 4 billion had access to tap water while another 2.3 billion had access to wells or public taps. 1.8 billion People still use an unsafe drinking water source which may be contaminated by faeces; this can result in infectious diarrhoea such as cholera and typhoid among others (Grandjean, 2004).

Esan land is situated on a relatively flat plateau called the Esan plateau (Segynola, 2015). It's approximately 466m above the sea level. Apart from the very few areas where there are remarkable valleys with exposed surface drainage, the study area is almost devoid of surface water sources. The water aquifer of Esan land is put at greater than 350m. This depth has also made it difficult to have access to underground water source in some part of the area (Akinbode, 1983; Segynola, 2015).

Of the 100 odd elements in the biosphere, 14 are trace minerals, occurring in biological tissue at concentrations of less than 0.01%. These elements function in many different ways, usually in close synergy with other minerals and trace elements. Micronutrients or micro minerals are required by humans and other organisms throughout life in small quantities to orchestrate a range of physiological functions (UNICEF, 2005). In humans generally, they are required in amounts less than 100 milligrams/day - as opposed to macro minerals which are required in larger quantities. The micronutrients include iron, cobalt, chromium, copper, iodine, manganese, selenium, zinc, molybdenum, strontium, Nickel and Silicon (Lieberman *et al*., 1990). Deficiency or lack of balance of the various minerals and trace elements is a frequent cause of a variety of disease conditions leading to poor health and failure to thrive (Bolarin, 2012).

Chromium's primary effects are on carbohydrate and lipid metabolism. It is an important factor in glucose tolerance as it enhances glucose tolerance, and it improves insulin receptors on cell membrane, thus, activating them to bind circulating insulin. It protects against diabetes. Deficiency leads to impaired glucose tolerance (type II diabetes mellitus) due to decreased insulin sensitivity (Vincent, 1999).Because of the specific transport mechanisms, only limited amounts of chromium enter the cells. Therefore, toxicity in humans is rare. Several invitro studies indicate that high concentrations of chromium in the cell can lead to DNA damage (Eastmond *et al.,* 2008).

Cobalt participates in the reactions of vitamin B12. Essential constituent of vitamin B12 and cobalt is very important for haemopoesis (Nielson, 1996). Deficiency of Cobalt leads to anaemia in Children while Toxicity leads to Beer-drinker's cardiomyopathy (Chiba, 1996).

Copper is a constituent of some enzymes (co factors) and very essential in their activity, e.g. Tyrosinase, lysyl oxidase (essential for cross- linkage in collagen polypeptides and elastin), monoamine oxidase, catalase, cytochrome, etc. Very important for erythropoiesis (as a component of enzymes of iron metabolism), It facilitates the absorption of iron. It is essential in the formation of haemoglobin (Bolarin, 2012). Dopamine monooxygenase is an enzyme which requires copper as a co factor and the enzyme converts dopamine to noradrenalin or norepinephrine an important neurotransmitter (Milne *et al.,* 1990). Copper metalloenzyme superoxide dismutase protects against free radical damage intracellularly and extracellularly in blood plasma by converting superoxide radicals to hydrogen peroxide and this is then removed (Stoeker, 1996). Deficiency of copper results in disease conditions such as; Menkes' disease (an inborn error or copper transport),Wilson's disease, Microcytic hypochromic anaemia and Toxicity leads to hepatolenticular degeneration , some biliary cirrhosis, hematemesis and melena, etc (O'Dell, 1996).

Manganese is a cofactor and activator of some enzymes E.g. Phosphatases, arginase -which is the terminal enzyme in urea formation in the liver. Superoxide dismutase is a mitochondrial enzyme which limits oxygen toxicity. Most enzymes involved in connective tissue synthesis or cholesterol or mucopolysaccharides. It is involved in insulin synthesis and bone formation (Kies, 1994).

A deficiency of manganese causes skeletal deformation in animals and inhibits the production of collagen in wound healing (Kies, 1994). Relatively high dietary intake of other minerals such as iron, magnesium, and calcium may inhibit the proper intake of manganese (Keen *et al*., 1996). Manganese toxicity can occur in miners of manganese ores - may result in Parkinson-like disorder and basal ganglia defects. Parenteral nutrition can cause increased plasma manganese. Toxicity of manganese may cause cholestasis, or hepatic disorder since it is excreted mainly in the bile (Kies, 1994).

Selenium is an antioxidant. It is present in erythrocyte glutathione peroxidase. It is an essential constituent of this enzyme. It is also present in Iodothyronine deiodinase, an enzyme responsible for converting T4 to biologically active T3. Selenium deficiency leads to cardiomyopathy (Kashan disease), skeletal muscle myopathy, muscle pain, muscle wasting, which responds to treatment with selenium supplements. It also leads to loss of mmunocompetence, thyroid function disorders due to combination of iodine and selenium depletion, reproductive disorders- male fertility may be affected (Ralston *et al*., 2008). Anxiety, confusion and hostility do respond to selenium supplementation (Sheehan *et al*., 1999).

Increased selenium intakes reduce the effects of mercury toxicity and it is now recognized that the molecular mechanism of mercury toxicity involves irreversible inhibition of selenoenzymes that are required to prevent and reverse oxidative damage in brain and endocrine tissues (Ralston *et al*., 2008). However, exceeding the Tolerable Upper Intake Level of 400 micrograms per day can lead to selenosis

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(selenium toxicity) (Wilber, 1980). Symptoms of selenosis include a garlic odour on the breath, gastrointestinal disorders, hair loss, sloughing of nails, fatigue, irritability, and neurological damage. Extreme cases of selenosis can result in cirrhosis of the liver, pulmonary edema, and death (Stadtman, 1996).

Zinc is an essential component of several enzyme systems (co factor), especially those concerned with protein and nucleic acid synthesis- DNA and RNA polymerases, including carbonic anhydrase and ALA dehydratase. Zinc is essential in wound healing, growth and sexual maturation, and insulin contains zinc (Bolarin, 2012). Zinc deficiency may be due to poor intake (parenteral nutrition), high quantity of dietary phytates or high utilization of zinc. Deficiency causes dermatitis, diarrhea, mental disturbance and lethargy. In infants, deficiency causes skin rashes (Klug and Schwabe, 1995), chronic diarrhea and intestinal malabsorption, growth retardation, and hypogonadism (Chiba, 1996). Zinc toxicity which may be due to excessive ingestion or inhalation of high concentrations of zinc oxide fumes leads to metal fume fever, pulmonary edema, jaundice and oliguria (Burtis *et al.,* 2006).

Iron has several vital functions. Examples include as a carrier of oxygen to the tissues from the lungs in the form of haemoglobin, as a transport medium for electrons within the cells in the form of cytochromes, and as an integral part of enzyme reactions in various tissues (enzymes such as the cytochrome oxidase, peroxidase, and catalase). It is essential cofactor for the hydroxylation of proline and lysine (Bolarin, 2012).

Common causes of iron deficiency include; Poor intake (due to insufficient iron in diet); impaired absorption due to mal-absorption or abdominal surgery; severe loss in females due to menstrual loss and in pregnancy due to greater demand by the developing embryo; gastrointestinal bleeding; tumours; parasitic infections like hook worm infection; tuberculosis; and salicylate ingestion, etc (Allen, 2002). Symptoms of iron deficiency are not unique to iron deficiency (i.e. not pathognomonic). Iron is needed for many enzymes to function normally, so a wide range of symptoms may eventually emerge, either as the secondary result of the anemia, or as other primary results of iron deficiency. They include; Anemia, Headache, increasing fatigue, Tachycardia, Exertional Dyspnoea, Ankle edema, Pallor (Kaplan *et al*., 1995), Perverted appetite, Sore mouth, Angular stomatitis, Thinning or spooning of nails (i.e. Koilonychia) and brittle nails (Plummer- Vinson syndrome), Dysphagia, Menorrhagia or Amenorrhea, Cardiac enlargement, Loss of hair and brittle hair (Halperin *et al*., 1998). Iron poisoning is an iron overload caused by a large excess of iron intake and usually refers to an acute overload rather than a gradual one. The first indication of iron poisoning following oral ingestion is abdominal pain usually localized to the epigastrium. This is due to the ulceration of the stomach lining. This is accompanied by nausea and vomiting. The pain then abates for 24 hours as the iron passes deeper into the body resulting in metabolic acidosis, which in turn damages internal organs, particularly the brain and the liver. The body goes into shock and death from liver failure (Tenenbein, 2005). Hence the aim of the study was toassess some of the micronutrients level in the domestic water sources in the study area.

METHODOLOGY

Study Area; The study area was Esan, commonly referred to as Esanland in Edo State, Nigeria.This area is located between latitude '6^0 10 and 6^0 45' north of the equator and between longitudes 6^0 10' and 6^0 30' east of the Greenwich Meridian (Akinbode, 1983). This comprises of the five (5) local government areas of Esan west, Esan central, Esan north-east, Esan south-west and Igueben. Esanland is located on a plateau; we have the top and bottom of sections of the plateau. The top section is essentially made up of Ekpoma, Uromi and Irrua settlements. The bottom section is essentially made up of Ubiaja, Igueben, Iruekpen, Ewu and Ewohimi (Segynola, 2015). For this study, Esanland was restricted to the headquarters of these local governments namely Ekpoma, Irrua, Uromi, Ubiaja and Igueben respectively. The 2006 national census put the population of the study area at 591,534 people (NGSA, 2006). Projected to 2015 at 2.8 percent national growth rate, the 2015 population of the study area is 740,601 people.

Sample Size Calculation: According to John (1991), to optimize a quality survey, a sufficient number of samples should be taken to obtain the desired precision. The more variable a water quality constituent is in time and space, the more frequently it must be sampled to achieve a given level of reliability. This method enabled us to estimate a minimum sample size for water quality sampling. This iterative method used in solving for the desired sample size (n) was:

$$n=\frac{t^2 s^2}{E^2}$$

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Where:
t= the value from the students't-table at a certain level of probability,
S= the standard deviation, and
E= the specified error.
The objective of the iterative process described here was to obtain a predicted *n* approximately equal to the calculated n.
For $t_{0.025}$, S= 1.414 and *E*= 2mg/L of DO (Dissolved Oxygen). At *n*= 10 (predicted), $t=_{0.025,\ 9}$ = 2.26 and $(2.26)^2(1.414)^2/2^2$= 2.55

Therefore, the predicted *n* is lower than the calculated n. At *n*= 5 (predicted), $t_{0.025,\ 5}$= 2.78 and $(2.78)^2$ and $(2.78)^2(1.414)^2/2^2$= 3.86

The predicted *n* was closer, but a lower predicted *n* was used, hence:
At n= 4 (predicted), $t_{0.025,\ 4}$= 3.182 and $(3.18)^2(1.414)^2/2^2$= 5.06. Since 4 < 5.06, this is close enough.

From this iterative procedure for determining a sample size, we found that the sample size should be between four and five samples from each area to achieve a specified error *E* of 2mg/L DO (Dissolved Oxygen) (John, 1991).

Sampling Technique; Multistage sampling technique was used for sample selection. The local government headquarters were distributed into highly populated quarters (using Google map satellite image of the study area) and 50% of the quarters selected. In each selected quarter, a count of streets/roads was undertaken, and proportionate allocation used to determine the number of houses required from each cluster. An estimate of the averages number of houses per street was obtained (21 houses). Random sampling was used to select houses in each street for sampling.

Forty-Five (45) water samples were collected from Rivers/Streams, underground water (boreholes), Rain drops collected into ground storage tanks known as Wells, in the study area.
(a) Five surface water samples were collected from the Ogedegbe River located at the top of the Esan plateau, and five surface water samples was also collected from the Ebah River located at the bottom of the Esan plateau.
(b) Samples were collected from Rain drops on metal roofing sheets of houses collected into wells in the study area at the top of the plateau, and five samples from the bottom of the Esan plateau.
(c) Five underground water samples (Boreholes), were collected from each of the five local government areas in the study area.
(d) In collecting surface water samples, surface water was collected from different points of the flowing sections of the river were the indigenes of that area usually get their water for domestic use.
(e) Five water samples were also collected from five different part of the warm spring water source on the outskirts of the agrarian town of Ikogosi-Ekiti in Southwest Nigeria as control. Water from the Ikogosi warm spring was used as control because serial research work carried out on this Natural water source shown that the biochemical, physiochemical and heavy metals levels were within the WHO permissible limit for drinking water.

The various sample sites were portions of the river and portions of the spring were water for domestic use was being sourced from by locals. Samples were collected from various boreholes early in the morning after allowing the water to pour away for about 30seconds.

Laboratory Analysis: All water samples were taken with a sampler into clean sterile plastic bottles and then brought to the laboratory. To stop growth of microbes', samples were frozen after collection. The samples were not pre-treated in any way. They were analyzed directly with the help of atomic absorption spectrophotometer as described by Walsh, (1962). Micronutrients were determined with the AA500 Atomic Absorption Spectrophotometer, which comprised of a Hollow Cathode lamp containing a coated cathode of the element that was to be analyzed used as the light source. The light source emits a beam of a specific wavelength across the barrier and into the monochromator. In practice, Atomic Absorption Spectrophotometry (AAS) methodology entails the aspiration of a sample into a flame, where it becomes atomized. A light beam is directed through the flame into a monochromator and onto a detector. The detector then measures the intensity of light absorbed by the atomized elements in the flame. Thus, the amount of light intensity absorbed in the flame is proportional to the element in the sample.

Statistical Analysis: The data generated from the laboratory analysis was subjected to basic statistical measurement and inter area comparisons was carried out to test for significant differences in the Micronutrients concentration using parametric analysis of variance (ANOVA) using the computer SPSS (Statistical Package for the Social Sciences) 20.0 windows application at 95% level of confidence using the appropriate Post Hoc.

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Table 1; Distribution of Micronutrients in Domestic water sources in study Area Subjected to One Way ANOVA Statistics (Values are Mean ± S.E.M)

Parameter	Fe(mg/l) (n=5)	Zn(mg/l) (n=5)	Cu(mg/l) (n=5)	Mn(mg/l) (n=5)	Cr(mg/l) (n=5)	Co(mg/l) (n=5)	Se(mg/l) (n=5)
Control	0.20 ± 0.06^{a}	0.08 ± 0.03^{a}	0.05 ± 0.01^{a}	0.12 ± 0.02^{a}	BL	BL	BDL
RnLP	0.32 ± 0.08^{a}	0.14 ± 0.06^{a}	0.08 ± 0.03^{b}	0.14 ± 0.05^{a}	0.01 ± 0.01^{a}	0.00 ± 0.01^{a}	BDL
RnUP	0.18 ± 0.05^{a}	0.15 ± 0.06^{a}	0.06 ± 0.02^{b}	0.15 ± 0.04^{a}	0.01 ± 0.01^{a}	BL	BDL
RLP	0.38 ± 0.01^{a}	0.43 ± 0.02^{b}	0.08 ± 0.01^{a}	0.11 ± 0.01^{a}	0.01 ± 0.00^{a}	0.01 ± 0.00^{b}	BDL
RUP	0.41 ± 0.03^{b}	0.04 ± 0.00^{a}	0.02 ± 0.00^{a}	0.14 ± 0.02^{a}	BL	0.01 ± 0.00^{c}	BDL
BWIg	0.14 ± 0.04^{a}	0.11 ± 0.03^{a}	0.03 ± 0.01^{a}	0.14 ± 0.03^{a}	0.01 ± 0.00^{a}	0.01 ± 0.00^{a}	BDL
BWUb	0.13 ± 0.04^{a}	0.14 ± 0.02^{a}	0.03 ± 0.01^{a}	0.06 ± 0.03^{a}	BL	BL	BDL
BWEk	0.48 ± 0.06^{c}	0.11 ± 0.03^{a}	0.03 ± 0.01^{a}	0.09 ± 0.04^{a}	BL	BL	BDL
BWIr	0.21 ± 0.09^{a}	0.17 ± 0.01^{a}	0.04 ± 0.01^{a}	0.12 ± 0.05^{a}	0.01 ± 0.00^{a}	0.01 ± 0.00^{a}	BDL
BWUr	0.10 ± 0.01^{a}	0.09 ± 0.00^{a}	0.03 ± 0.01^{a}	0.10 ± 0.03^{a}	BL	BL	BDL
F-ratio	6.65	11.08	2.25	0.73	0.58	2.38	.
p-Value (p<0.05)	0.00 (S.)	0.00 (S.)	0.04 (S.)	0.68 (N.S)	0.80 (N.S)	0.03 (S.)	.

Note: Values in a column with different superscripts are statistically significant at P<0.05

Keys: IKWS: Ikogosi warm spring; RnLP= Rain water collected in wells in Lower plateau; RnUP= Rain water collected in wells in Upper plateau; RLP= River in lower plateau, RUP= River in upper plateau; BWIg= Borehole water from Igueben; BWUb= Borehole water from Ubiaja; BWEk= Borehole water from Ekpoma; BWIr= Borehole water from Irrua; BWUr= Borehole water from Uromi; n: Number of sample; P<0.05: Significant; P>0.05: Not Significant; NS: Not Significant; S: Significant; Fe: Iron; Zn: Zinc; Mn: Manganese; Cr: Chromium; Cu: Copper; Se: Selenium; Co:Cobalt ; BDL: Below detectable limit; S.E.M= Standard error of Mean; BL: Below limit (i.e. values less than 0.01

RESULT

Results of the analysis showed that Selenium levels were below the detectable limit in both the study area and Control samples.

As shown in Table 1, when the control water from the Ikogosi warm spring Iron levels was compared with the Iron (Fe) levels of water samples from the study area, it was statistically significant for Borehole water from Ekpoma (BWEk) (p = 0.00) and River water from upper plateau (RUP) (p=0.01). Multiple comparisons using the Post Hoc Test showed that Fe levels in River water from lower plateau (RLP)(p=0.03), Borehole water from Igueben (BWIg)(p=0.02), Borehole water from Ubiaja (BWUb)(p=0.01), Borehole water from Ekpoma(BWEk)(p=0.01) and Borehole water from Uromi (BWUr)(p=0.01) were significantly lower in comparison with RnLP. The Fe levels of the other groups in comparison with the control were not statistically significant (p> 0.05).

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Zinc(Zn) levels in River water from the lower plateau (RLP) was statistically significant(P=0.00) in comparison with the control (IKWS), but in comparison with the control, Zn levels of Rain water from lower plateau (RnLP), Rain water from Upper plateau (RnUP), River water from upper plateau (RUP), Borehole water from Igueben (BWIg), Borehole water from Ekpoma (BWEk), Borehole water from Ubiaja (BWUb), Borehole water from Irrua (BWIr) and Borehole water from Uromi (BWUr) were not statistically significant ($p > 0.05$). Multiple comparisons with the post hoc test showed that Zn levels of Rain water from lower plateau (RnLP)(p=0.00), Rain water from Upper plateau (RnUP)(p=0.00), River water from upper plateau (RUP)(p=0.00), Borehole water from Igueben (BWIg)(p=0.00), Borehole water from Ekpoma (BWEk) (p=0.00), Borehole water from Ubiaja (BWUb)(p=0.00), Borehole water from Irrua (BWIr)(p=0.00) and Borehole water from Uromi (BWUr)(p=0.00) were significantly lower in comparison with River water from the lower plateau (RLP).

The control when compared with the Cu levels of water samples from the study groups, it was statistically not significant ($p > 0.05$) .But multiple comparisons using the Post Hoc Test showed that the Cu levels of Rain water from lower plateau (RnLP), Rain water from Upper plateau (RnUP) and River water from lower plateau were significantly higher in comparison with Borehole water from Igueben (BWIg)(p=0.02), Borehole water from Ubiaja (BWUb)(p=0.03), Borehole water from Irrua (BWIr)(p=0.04), Borehole water from Uromi (BWUr) (p=0.02)and Borehole water from Ekpoma (BWEk)(p=0.02).

Mn and Cr levels of the domestic water sources in the study area when compared with Mn and Cr levels of the control (IKWS) were not statistically significant($p > 0.05$).

In comparison with the control, Cobalt (Co) levels of water samples from the study area was statistically significant for River water from upper plateau (RUP) and River water from the lower plateau (RLP) (p=0.03).

The study showed that the Iron (Fe) level in borehole water from Ekpoma and River water samples from the upper plateau was significantly higher. Enuneku *et al.,* (2013) reported a significant level of Fe in River samples from River Owan in Edo State. Fe levels higher than the control was also observed for Rain water from the lower plateau and River water from the lower plateau, though statistically it was not significantly higher. It is generally known that the chemical composition of groundwater is mainly determined by the composition of the rock it is extracted from, but depending on the geochemical processes, similar types of rocks may lead to a range of chemical constituents in the groundwater (Razowska-Jaworek, 2014), Therefore the water aquifer of Ekpoma which is put at greater than 350m depth might be responsible for the significant level of Iron. In a study of the ground water quality in the Eastern part of the Niger-Delta by Amadi *et al.,* (2014) using multivariate geostatistical techniques, and hydrological investigations showed that the iron-rich water aquifer occurred at greater than 175m depth. Though the Fe levels was statistically significant in comparison with the control, but its levels in Ekpoma borehole samples and River samples didn't exceed the WHO permissible limit of 3.00 mg/l for drinking water.

Iron is an essential element in human nutrition, and the health benefits of iron in drinking water may include warding off fatigue and anaemia. What is noticed the most from water that is high in iron is that the water may taste metallic, the water may be discoloured and appear brownish, and it may even contain sediment. Iron will leave red or orange rust stains in the sink, toilet and bathtub or shower. It can build up in the dishwasher and discolour ceramic dishes. It can also enter into the water heater and can get into the laundry equipment and cause stains on clothing. Although iron in drinking water is safe to ingest, the iron sediments may contain trace impurities or harbor bacteria that can be harmful. Iron dissolving bacteria are naturally occurring organisms that can dissolve iron and some other minerals. These bacteria also form a brown slime that can build up in water pipes. Iron bacteria are most commonly problematic where water has not been chlorinated. Ingesting too much iron through drinking water is rare (WHO, 2004). However, while chronically consuming large amounts of iron can lead to a

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condition known as iron overload; this condition is usually the result of a gene mutation that afflicts about one million people in the United States and when this condition is left untreated, could lead to haemochromatosis (an hereditary disorder in which there is excessive absorption and storage of iron), a severe disease that can damage the body's organs. Early symptoms include fatigue, weight loss, and joint pain, but if haemochromatosis is not treated, it can lead to heart disease, liver problems and diabetes (O'Malley and O'Malley, 2012).

From this study Zn levels in water samples collected from the river in the lower plateau (RLP) was statistically significant in comparison with the control (IKWS). Chinyem, (2010), in Agepanu and Environs in Edo State reported the presence of zinc in surface water. Enuneku *et al*., (2013) also reported a significant level of Zn in River Owan in Edo State. Although the Zinc concentration was significant in river water from lower plateau (RLP), the values didn't exceed the WHO permissible limit of 5.0mg/l for drinking water. Hence, the Zinc levels are beneficial as an essential trace element to humans and animals in general when ingested. It is called an "essential trace element" because very small amounts of zinc are necessary for human health (hence referred to as micronutrient). The health benefits of Zinc include proper functioning of the immune and digestive systems, control of diabetes, reduction of stress levels, energy metabolism, and an increased rate of healing for acne and wounds. Also, zinc is helpful in terms of pregnancy, hair care, eczema, weight loss, night blindness, colds, eye care, appetite loss and many other minor conditions (Singh and Das, 2013). Zinc, being an important mineral, plays a vital role in protein synthesis and helps regulate the cell production in the immune system of the human body. Zinc is mostly found in the strongest muscles of the body and is found in especially high concentrations in the white and red blood cells, eye retina, skin, liver, kidneys, bones and pancreas. The semen and prostate gland in men also contain significant amounts of zinc (Prasad *et al*., 2007).

The study showed that Copper was not statistically significant in comparison with the control, But the Cu levels of Rain water from lower plateau (RnLP) and upper plateau (RnUP) in comparison with Borehole water from Igueben (BWIg), Borehole water from Ekpoma (BWEk), Borehole water from Ubiaja (BWUb), Borehole water from Irrua (BWIr) and Borehole water from Uromi (BWUr), were significantly higher.

The major applications of copper are in electrical wires and materials, roofing, plumbing and industrial machinery as well as pigments (Johnson, and Larry, 2008), from where it must have been leach (washed) by rain water into these wells.

This study showed that Cobalt was statistically significant for River samples from the lower plateau (RLP) and Upper plateau (RUP). This agrees with the work done by Akan *et al.,* (2007), in Water from River Challawa in Kano Industrial Area, Kano State, which has similar topography as this area. Cobalt occurs naturally in soil and rocks, in plants and animals as a major component of vitamin B12. The significant level of cobalt in RLP and RUP is much likely as a result of rain water washing through soil containing decomposed plants and animals or their remains. Cobalt compounds are also used as trace element additives in agriculture and medicine (ASTDR, 2004).

Esan land has very few industries and little commercial agricultural activities, this may account for the non-significant to non-detectable levels of Chromium, Manganese and Selenium in the area. The presence of micronutrients/ trace elements in the borehole water samples is notable because Micronutrients or micro minerals are required by humans and other organisms throughout life in small quantities to orchestrate a range of physiological functions (UNICEF, 2005).

CONCLUSION

Some Micronutrients levels in borehole water, rain water collected into ground storage tanks (commonly referred to as wells) and water from rivers in the upper and lower plateau in Esanland, Edo State were determined in these domestic water sources. Some parameters determined were found, but Selenium was not within detectable limit. The micronutrients determined in underground (borehole) water samples were not greater than the World health organizations (WHO) permissible limit for these parameters.

Therefore, sufficient data from this research has shown that most underground water sources in Esanland maybe suitable for drinking and domestic use. But the surface water (river water from the upper plateau and lower plateau) and rain water collected into ground storage tanks (commonly referred to as wells) would require treatment before it can be considered suitable for domestic use. At the end of this study, the objective of determining some micronutrients levels of the various domestic water sources in Esanland was fulfilled and sufficient data on some micronutrients was obtained.

RECOMMENDATION

We recommend the following;

i. Quality assessment of existing boreholes to ascertain the quality of the water before allowing for public utilization by appropriate regulatory agencies.
ii. Intake of food and vegetables rich in micronutrients to compensate for low levels in the water.
iii. Public health education by public health workers on the importance of micronutrients.
iv. Further assessment of heavy metals and other biochemical parameters be carried out to further determine the water quality of the study area.

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