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CHEMICAL EXAMINATION OF PIPED WATER SUPPLY OF ILE-IFE IN SOUTHWEST NIGERIA

[1]M. O. Orewole, *[3]O. W. Makinde, [2]K. O. Adekalu, [4]K. A. Shittu

[1]Institute of Ecology and Environmental Studies, Obafemi Awolowo University, Ile-Ife, Nigeria

[2]Department of Agricultural Engineering, Obafemi Awolowo University, Ile-Ife, Nigeria

[3]Centre for Energy Research and Development, Obafemi Awolowo University, Ile-Ife, Nigeria

[4]Department of soil sciences, University of Ibadan, Nigeria

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ABSTRACT

This study was undertaken to determine the changes in the physico-chemical properties of piped water supplied in the state, between the treatment plant and points of use in Ile-Ife, Nigeria. Thirteen samples of water were collected at different locations from treatment plant to the points of use and analyzed for the following selected parameters: alkalinity, total dissolved solids, total suspended solid, total solid, potassium, sodium, calcium, magnesium, trace metals, sulphate and chloride. The results revealed that between treatment plant at Ede and the point of use, there are changes in the considered physico-chemical properties of the water supply.The most significant is the concentration of lead ion which was higher than the recommended 0.01mg/L by the world health organization and total alkalinity with a mean value of (325.36±81.85) mg/L. The study concluded that the treatment process needs to be reviewed to identify the possible source of the ion and put necessary prevention procedures.

Key words: Point of use, physico chemical, trace metals, water quality, alkalinity, piped water

INTRODUCTION

The combination of unsafe drinking water and inadequate sanitation facilities constitutes one of the major causes of death and disability as a result of water borne diseases, which is often on epidemic scale among the poor in developing countries. Safe, convenient water supply and adequate sanitation is a fundamental component of broad-based economic growth strategies. Lowering mortality and morbidity from water and sanitation-related diseases is a goal in itself; it can also lead to increased productivity among members of the labour force and can reduce the time and energy burden on the household, leading to more time for crop cultivation, child care, and income-generating activities, as well as more regular school attendance (USAID, 1982). Water is essential for growing food; for household uses, including drinking, cooking, and sanitation; as a critical input into industry; for tourism and cultural purposes; and for its role in sustaining the earth's ecosystems (Mark *et al*., 2002). Water is one of the most abundant resources in the world. It covers a substantial part of the earth's surface, filling the oceans, rivers and lakes and exists as vapour in the air and as underground water. Despite the abundance of water, large percentage of the populations in Nigeria and other parts of the world hardly have enough to drink and meet the essential needs as the provision of portable water has, for long, been a major problem, this is associated with poverty, a common stance in most developing parts of the world, (Ashbolt, 2004). The estimated total amount of water on earth is 1360 million Km^3 but only 4 million Km^3 (or 0.3%) is available for human use as fresh water in rivers, streams, springs and aquifers. The remaining 1356 million Km^3 (or 99.7%) is locked in seas and oceans, (Wilson, 1978). Water demand varies depending on the intended use, available sources and socio-economic situation of any population. Mark *et al*., (2002)

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*Corresponding author-Email: *dotmark4great@yahoo.co.uk*
Telefax: +23 4803951110

classified water demand as irrigation and non-irrigation demand, the latter further disaggregated into domestic, industrial, and livestock demand. It is however, a transparent fact, that much of the water demand cannot be met by present supply in most developing countries and both water quantity and quality are inadequate to support healthy living standards for the growing urban masses that do not have access to piped water and sewer services, so disease and malnutrition increase dramatically (Mark *et al.*, 2002). Water from dug wells, streams and even, boreholes are mostly inadequately treated and are associated with various health risks mainly because they are victims of pollution from domestic sewage effluents and other forms of environmental pollutions. Even the bore holes are very shallow in depth and cannot be a reliable source of water for domestic and even, industrial uses. The need for a better treated water has led to the dependent, by a large percentage of the population in Nigeria, on public treated pipe-borne water as the only available source of treated water for use considering the high cost of water treatment and purification by individuals and this has evoked the need for time to time monitoring of the treatment processes of screening, coagulation, disinfection, precipitation, adsorption, storage and distribution, through a standard laboratory procedure, the qualities of pipe-borne water distributed for use by the public, hence, the focus of this research work.

MATERIALS AND METHODS

One litre samples of water were collected in clean white plastic bottles from thirteen sampling stations between the storage reservoir of the treatment plant at Ede and points of use in ILE-IFE according to standard procedures described in the sampling guide (DWAF, 1992; DWAF, 1999). The samples were kept at 4^{o}C prior to laboratory analysis and were analysed within 24 hours. The sample bottles were previously soaked in soap solution, treated with 5% Nitric acid for 24hrs and rinsed severally with doubly distilled water prior to use (DWAF, 1992; DWAF, 1999). The samples were also acidified with 5 mL nitric acid (conc). During sampling, the bottles were first rinsed with the sample water several times to preclude trace metal contamination. Fig. 1 shows the sampling stations: Digestion of the samples was done using standard methods by APHA, 1992. Exactly 2.5 mL of conc. HNO_3 was added to 25 mL of the sample in a clean Teflon beaker. This was heated on a water bath to concentrate the sample to about 10 mL.

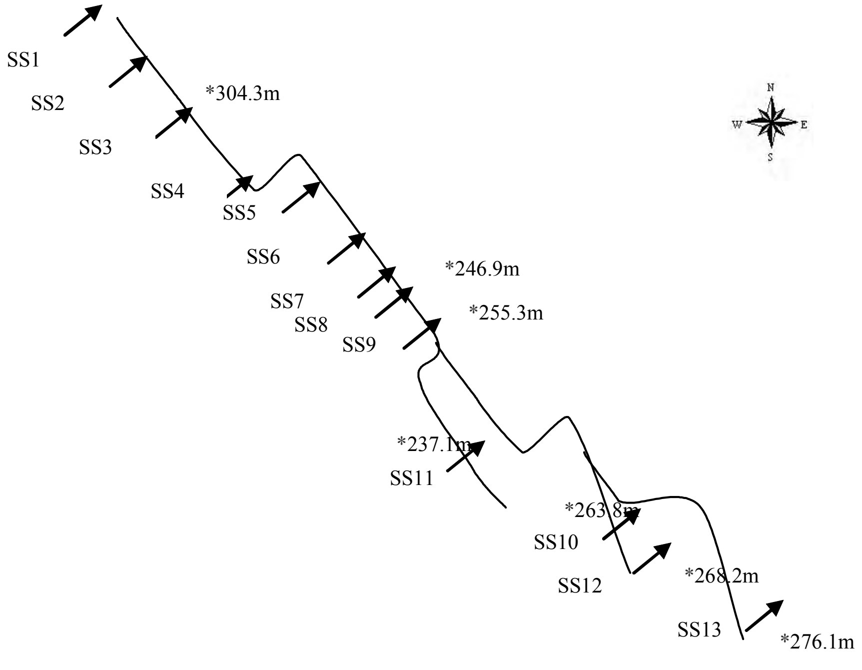

Fig. 1: Schematic representation of the sampling stations between the treatment plant and points of use in ILE-IFE

Heating continued with periodic addition of 1 mL conc. HNO_3 until a clear solution was obtained. This was allowed to cool and then transfer into clean 25 mL flask, made up to mark with distilled water and kept for analysis. The Alpha 4 Atomic Absorption Spectrometer (Chem. Tech Analytical) of the Centre for Energy Research and Development, Obafemi Awolowo University, Ile-Ife, Nigeria was used to analyze for sodium, potassium, calcium, and magnesium and seven heavy metals namely Pb, Cd, Co, Mn, Zn, Cu, and Fe in the samples by flame atomization, using air-acetylene flame and single element hollow cathode lamp and following the equipment procedures (Weltz, 1985 and Beaty, 1988). Measurement was done at 589.0, 766.5, 422.7 and 285.2 nanometers for major elements and 217.0, 228.8, 240.7, 285.2, 213.9, 324.7 and 248.3 nanometers for heavy metals respectively. Analysis of water samples for total dissolved solid (TDS), total suspended solid (TSS) and total solid (TS) was done by gravimetric method (Ademoroti, 1996). Total alkalinity, chloride (Cl^-) and sulphate (SO_4^{2-}) concentrations were determined according to the standard procedures (Ademoroti, 1996 and APHA, 1976).

RESULTS

The variation in the values of total dissolved solid (TDS), total solid (TS), total suspended solid (TSS) and total alkalinity for the water samples is shown in Table 1. The value of total alkalinity, from the point of treatment to the point of use is generally high. It ranges from 200mg/L for clarified water to 425 mg/L at two points of use in ILE-IFE. The concentrations of selected anions (negatively charged ions) are shown in Table 2. From the Table, the concentration of Cl^- in the raw water is 2.23 mg/L and increases to 7.20 mg/L at the chlorination point (Table 2). There is however, a decrease in the concentration of Cl^- along the distribution line to the points of use, with the lowest value (2.132 mg/L) recorded at More street, in Ile-Ife. Similarly, the mean value of SO_4^{2-} (43.01±5.18) mg/L is far below the maximum allowable concentration for sulphate ions in drinking water by WHO which is 250mg/L. The concentrations of selected cations (positively charged ions) are shown in Table 3 and shows the concentration of K^+ in the raw water as 5.56 mg/L which increases to 8.92 mg/L after treatment. There was a decrease in the concentration of K^+ along the distribution line to the points of use. The mean value of K^+ in the study is (11.64±3.29) mg/L. Similarly, the concentration of Na^+ (9.98 mg/L), in the raw water increases to 16.73 mg/L after treatment. There was also a decrease in the concentration of Na^+ along the distribution line (Table 3) to the points of use with values that comply with the WHO drinking water standard. The mean values of Ca^{2+} and Mg^{2+} obtained in

Table 1: Result of laboratory analysis of total alkalinity, TS, TDS and TSS of the collected water samples

Sample station	Description	Total solids (TS) (mg/L)	Total dissolved solids (TDS) (mg/L)	Total suspended solids (TSS) (mg/L)	Total alkalinity (mg/L)
S1	Raw water	400	110	290	350
S2	Clarified water	46.67	31.67	15	200
S3	Chlorinated water	140	75	65	375
S4	Ede town	145	72.5	72.5	374
S5	Sekona	172	91.44	80.56	360
S6	Edun abon	191	106.27	84.73	359
S7	Before reservoir	200	105	95	350
S8	Ede road in Ife	180	90.44	89.56	425
S9	Booster station	180	105	75	425
S10	Lagere in Ife	252	161.74	90.26	305
S11	Modakeke in Ife	265	129.02	135.98	202
S12	Fajuyi in Ife central	343.33	158.33	185	200
S13	Moore in Ife east	345	161	201.56	204
Stds		*2500	**500	*50	**500

Note: *F.E.P.A limits, **E.P.A limits

this study are (2.56±0.49) mg/L and (1.96±0.48) mg/L are values, compared to WHO limit of 50 mg/L. The results of analysis of the water samples to determine the concentration of trace metals are as presented in Table 4. A careful study of the Table reveals that of all the elements analyzed, only lead showed a significant level, which is clearly higher than the 0.01mg/L limit, recommended by the WHO for water meant for domestic purposes. The concentration of Pb in the raw water is 0.170±0.020 mg/L which decreases to 0.022±0.002 mg/L after treatment and again increases to 0.083±0.010 mg/L at S3, this increase however became steady from the point of use at Ede town to Ede road in Ile-Ife and again increase steadily at different points of use in Ile-Ife. However, there is a slight increase in the concentration of Cd (0.002±0.000) mg/L and Cu (0.002±0.001) mg/L respectively after the treatment process.

Table 2: Result of laboratory analysis of chloride ions and sulphate ions in the collected water samples

Sample station	Description	Cl^- (mg/L)	SO_4^{2-} (mg/L)
S1	Raw water	2.233	37.75
S2	Clarified water	5.596	37.75
S3	Chlorinated water	7.196	45.25
S4	Ede town	6.260	45.25
S5	Sekona	5.863	45.25
S6	Edun abon	5.670	45.25
S7	Before reservoir	5.596	45.25
S8	Ede road in Ife	2.233	42.56
S9	Booster station	2.233	30.25
S10	Lagere in Ife	2.233	35.46
S11	Modakeke in Ife	2.233	42.68
S12	Fajuyi in Ife central	2.233	47.75
S13	Moore in Ife east	2.132	48.25

Source: Laboratory Analysis

Table 3: Result of laboratory analysis of potassium, sodium, calcium and magnesium in the collected water samples

Sample station	Description	K^+ (mg/L)	Na^+ (mg/L)	Ca^{2+} (mg/L)	Mg^{2+} (mg/L)
S1	Raw water	5.56	9.98	3.64	1.92
S2	Clarified water	6.44	9.30	1.14	1.19
S3	Chlorinated water	8.92	16.73	3.43	2.46
S4	Ede town	8.54	17.02	3.41	2.31
S5	Sekona	7.32	17.13	3.12	1.92
S6	Edun abon	6.54	9.27	2.58	1.62
S7	Before reservoir	5.30	9.25	2.31	1.40
S8	Ede road in Ife	4.12	9.22	2.20	1.35
S9	Booster station	4.91	9.22	2.17	1.27
S10	Lagere in Ife	5.18	9.34	2.18	1.82
S11	Modakeke in Ife	5.36	9.85	2.21	2.35
S12	Fajuyi in Ife central	5.48	10.26	2.25	2.50
S13	Moore in Ife east	5.52	10.76	2.26	2.61

Source: Laboratory Analysis

Table 4: Concentration (mg/L) of Heavy metals in the water samples

Sampling points	Pb	Cd	Co	Zn	Fe	Cu	Mn
S1	0.170	0.001	0.020	0.001	0.150	0.002	0.085
S2	0.022	0.000	0.001	0.316	0.200	0.000	0.118
S3	0.083	0.002	ND	0.168	0.150	0.002	0.018
S4	0.101	0.002	ND	0.160	0.080	0.005	0.004
S5	0.101	0.001	ND	0.108	0.090	0.004	0.004
S6	0.112	0.000	ND	0.158	0.078	0.005	0.003
S7	0.100	0.003	ND	0.162	0.082	0.003	0.004
S8	0.104	0.001	ND	0.161	0.080	0.002	0.003
S9	0.098	0.000	ND	0.161	0.080	0.003	0.029
S10	0.111	0.002	ND	0.158	0.079	0.003	0.003
S11	0.103	0.002	ND	0.144	0.080	0.002	0.002
S12	0.122	0.001	ND	0.139	0.088	0.001	0.002
S13	0.121	0.002	ND	0.138	0.083	0.001	0.001
Ref.Smpl	0.001	0.000	0.000	0.000	0.000	0.002	0.000

DISCUSSION

Except for Total Alkalinity, the values of TDS, TS and TSS fall within the maximum allowable limits of WHO (1000 mg/L).Dissolved solids” refer to any minerals, salts, metals, cations or anions dissolved in water while total dissolved solids (TDS) comprises inorganic salts (principally calcium, magnesium, potassium, sodium, bicarbonates, chlorides and sulphates) and some small amounts of organic matter that are dissolved in water. An elevated total dissolved solids (TDS) concentration is not a health hazard as the TDS concentration is a secondary drinking water standard and is more of an aesthetic rather than a health hazard. An elevated TDS may be an indicator of the concentration of dissolved ions which may cause the water to be corrosive, salty or brackish taste, resulting in scale formation, and interfere with and decrease efficiency of hot water heaters. It may also interfere with washing clothes and corroding plumbing fixtures. The total alkalinity value of water is an indication of the acid-neutralizing ability of the water and is determined by how much carbonate, bicarbonate and hydroxide is present. Excessive alkalinity levels may cause scale formation, the water may also have a distinctly flat, unpleasant taste. In the present study, the value of total alkalinity, from the point of treatment to the point of use is generally high and this high value, especially at the two points of use, may be traceable to dissolution of the distribution pipes into the water, ageing of these pipes and intrusion from leakages. A better treatment process to drastically reduce the value of total alkalinity before supply and replacement of the ageing distribution pipes should be employed by the water corporation. High chloride content in drinking water may indicate possible pollution from human sewage, animal manure or industrial wastes, factors which are all absent in piped water. The values recorded in the study are much lower than the WHO limits of 250 mg/L for Cl^- water meant for drinking purpose. Similarly, the mean value of SO_4^{2-} (43.01±5.18) mg/L is far below the maximum allowable concentration for sulphate ions in drinking water by WHO which is 250 mg/L. High concentration of Sulphate ions, though not a significant health hazard, can cause scale build-up in water pipes and may be associated with a bitter taste in water that can have a laxative effect on humans and young livestock. Elevated sulphate levels in combination with chlorine bleach can also make cleaning clothes difficult (Adams, 2001). A careful study of the Table reveals that of all the elements analyzed, only lead showed a significant level, which is clearly higher than the 0.01 mg/L limit, recommended by the WHO for water meant for domestic purposes. The EPA also recommends additional purification steps to be taken for drinking water containing more than 0.015 mg/L of Pb (EPA, 2006). The decrease in the concentration of Pb in the raw water from 0.170±0.020 mg/L to 0.022±0.002 mg/L after treatment suggests that the soluble ions removing process of precipitation, employed in the treatment process, is only 87% effective in removing the Pb ions in the raw water. The increase in concentration of Pb to 0.083±0.010 mg/L at S3 can be attributed to added impurities in the further treatment process; this increase however became steady from the point of use at Ede town to Ede road in Ile-Ife and again increase steadily at different points of use in Ile-Ife. This increase in the concentration of Pb ions in the samples might not be unconnected with the corrosion of the lead pipes used in the distribution of the water from the treatment area at Ede to the different points of use as the use of lead piping of public water, which has for long been discouraged in most parts of the world is still in use in most of the studied areas. Nevertheless, in all the points of use, the concentration of Pb ions was clearly higher than the 0.01mg/L WHO limit and above the 0.015 mg/L EPA action level and as such calls for concern. The case is simplified for other trace metals, as their concentrations were all lower than the recommended limits at the different points of use. The slight increase in the concentrations of Cd and Cu which suggests the addition of the ions through the use of impure chemicals. Thus calling for a complete overhaul or purification of the chemicals prior to use. The absence of Co in the water samples at all the points of use as seen from the Table might be due to the fact that Co forms many complex compounds owing to its transition states which when released into water or soil sticks to particles without dissolving. Trace metals are important water pollutants. While some e.g. Zn and Cu are essential metals, others such as Pb and Cd are very toxic to humans when consumed above limits. Pb poisoning causes, abdominal pain, irritability, slurred speech, mental retardation and anemia amongst others. The increase in concentrations of Na and K ions at the point of treatment is due to the formation of the chlorides, the forms in which the metals are readily soluble, as a result of the processes of chlorination, and this may also account for the high concentrations of the ions at S_4 and S_5, two points immediately after treatment. There was also a decrease in the concentration of Na^+ along the distribution line (Table 3) to the points of use with values that comply with the WHO drinking water standard. The low value recorded for the two ions are justifiable, since the regular sources of Na and K ions in surface and ground water are absent in piped water. There are no health-based drinking water standards for potassium but sodium, as a result of its implication in hypertension, is set at 200mg/L limit by the World Health Organisation (Nkono *et al.*, 1997) and as such, a high concentration of it may be a concern for people. Ca and Mg are essential elements needed in good quantity by the human body while Ca is used in teeth and bone formation; it also plays an important role in neuromuscular extractability, and for good functioning of the conducting myocardial system, heart and muscle contractibility and also for blood coagulability (Frantisek K, 2003). Calcium and magnesium are important contributors to water hardness. When water is heated, they break down and precipitate out of solution, forming scale and although, maximum limits have not been established, magnesium concentrations greater than 125 mg/L may have a laxative effect on some people. The low mean values of Ca^{2+} and Mg^{2+} obtained from water samples collected at different points of use compared to WHO limit of 50 mg/L, may be attributed to an efficient water softening process employed in the treatment to remove hardness from the water. The Scientific Committee for Food and the Committee on dietary reference intake has recommended a daily Ca intake of between 700 and 1000 mg for adults.

Suitability of the piped-water for community uses

For all the parameters considered in this study, it is concluded that with the exception of Pb, all other parameters studied are within the maximum allowable limits of WHO except for total alkalinity which however, is not of serious health impact. However, the concentration of lead was clearly above standards in all the samples at different points of use, the water will therefore be safer for drinking purpose and other household uses if necessary action could be taken to step up the purification process in other to prevent the addition of the ion through the use of unpurified chemicals in the processes of coagulation, chlorination and precipitation.

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