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Research paper

Analysis of variation of water quality parameters along treatment processes in OPA waterworks, ILE-IFE, Nigeria

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Abstract

This study was conducted to assess the variation of water quality parameters along the treatment processes of Opa Waterworks at Obafemi Awolowo University, Ile – Ife, Nigeria. This was to ascertain how chemical and physical parameters vary along the treatment plant visits while at the same time ensuring that the influent and effluent conforms to water quality standards set by the World Health Organization. Determination of physicochemical parameters; pH, temperature, conductivity, turbidity, nitrate and chloride was done by using standard methods while a colorimetric, and atomic absorption spectrometry methods were used for the selected heavy metals; cadmium, zinc and copper.

It was observed that for the influent, the concentration of lead was 9.44 mg/l, nitrate 0.25 mg/l, chloride 18.27 mg/l, sulphate 4.29 mg/l, copper 4.55 mg/l, zinc 0.07 mg/l and cadmium 1.10 mg/l. For the effluent, the concentration of nitrate was 0.22 mg/l, chloride 16.01 mg/l and sulphate 4.29 mg/l while that of lead, copper, zinc and cadmium was 0.00 mg/l. The overall results show that the concentrations of the water quality parameters tested conform to the World Health Organization water quality standards at the effluent points of the treatment plant.

Keywords: *Water Treatment; Turbidity; Heavy Metals; Chloride; Sulphate; Nitrate; Conductivity; Treatment Plant.*

1. Introduction

Water quality is a measure of the suitability of water for human consumption. According to Acquavita et al, (2015), water is considered potable when it is free from contaminants that can cause diseases after going through various water treatment processes in a water treatment plant. The essence of highly potable water can therefore not be overemphasized in an effort to keep epidemics and diseases away from the populace. These contaminants can be classified into organic, inorganic and microbiological contaminants. Inorganic contaminants consist of nitrates, phosphates, chlorides, hydrogen sulphide and heavy metals. They are contaminants which do not have carbon compounds but are nevertheless elements or compounds that are found in water (Agarwal, 2010).

Opa dam waterworks is the major source of water for the Obafemi Awolowo University community having a pumping capability of four million litres per day. It comprises of the intake, aeration, coagulation/ flocculation, sedimentation, filtration , disinfection and distribution units. The treated water from the water works is used for a number of activities such as cooking, washing, laboratory analysis, etc. (Asadullah and Khan, 2013; Mena-Rivera et al., 2017). Hence, if the treated water does not meet the required quality standards, there may be an outbreak of diseases related to poor water quality; an example of this is the outbreak of scabies in 1993/1994 due to the supply of untreated water from a local river to a community in Ijebu – Ode (Balamurugan and Dheenadayalan, 2012; Gazzaz, 2012).

Living organisms also require trace amounts of some of these contaminants such as cobalt, copper, iron, manganese, molybdenum, vanadium, strontium and zinc. Hence, Opa waterworks which is the major source of water to the university must therefore be monitored and if possible treated for the prevalence of disease-causing organisms and "contaminants" so as to ensure that the natural balance in the community as far as water use is concerned is maintained thereby preventing any catastrophes from happening in the community (Gopalkrushna, 2011; Jeje and Oladepo, 2018; Jeje and Oladepo, 2019).

This study was limited to the analysis of water samples from Opa waterworks for the pH, conductivity, turbidity, chlorides, nitrates, copper, cadmium, lead and zinc using atomic absorption spectrometry, colorimetric methods and electronic/manual appliances in the field.

2. Materials and methods

The materials and equipment that were used in this study are water (obtained from Opa Dam), thermometer, pH meter, conductivity meter and colorimeter. The water samples were collected at different locations along the treatment units of the treatment plants. This includes

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raw water from the aeration unit, settled water from the sedimentation unit, filtered water from the filtration unit, treated water from the clear well and taps.

2.1. Determination of physicochemical parameters

2.1.1. Temperature and pH

This was determined with the aid of a thermometer. The temperature was taken at the sample collection point before and after collection. The ambient temperature of the location was also taken. The pH was determined using a pH meter immediately after all the samples were collected on site.

2.1.2. Conductivity

This was determined in the laboratory with the aid of a conductivity meter. The meter was first standardized with distilled water which also served as control. The rod was then inserted into each sample and the reading was taken. The readings were done the same day the samples were collected as conductivity changes with storage time.

2.1.3. Colour

This was determined with a colorimeter at 430 µm wavelength. All the samples were sub-sampled into beakers, then a small tube was used to take the sample, the body of the tube was cleaned with tissue paper then put into the colorimeter and the readings were taken in percentage transmission.
The colour concentration was calculated using Equation (1).

$$Y = 2864.9 - 28.83X \quad (1)$$

Where X = percentage transmission and
Y = concentration of colour in Pt-Co

2.1.4. Turbidity

This was determined with colorimeter at 430 µm wavelength. All the procedures for colour determination were followed and the readings were taken in percentage transmission, then the calculation was done using the Equation (2) .

$$Y = 275.5 - 2.79X \quad (2)$$

Where X = percentage transmission
Y = concentration in NTU (Nephelometric Turbidity Unit)

2.1.5. Chloride

Volumetric method using mercury nitrate, $Hg(NO_3)_2$, reagent was used for the determination of chloride in the samples. 50 ml of each sample was sub sampled into the volumetric flasks using a pipette. 5 drops of the indicator (diphenylcarbazone-bromophenol blue) was then added to the sample. 0.2 M HNO_3 acid was added drop-wise until there was a slight colour change, and then 5 drops were added. Each sample was titrated with $Hg(NO_3)_2$ until there was first a tinge of bluish-purple which did not disappear on shaking, then purple colour was developed after some time. The concentration of samples in mg/l were calculated using Equation (3).

$$Y = 22.88X - 0.94 \quad (3)$$

Where X = average titre value and
Y = concentration of chloride in mg/l

2.1.6. Nitrate

Colorimetric method was used by measuring 25 ml of each sample into beakers. The beakers were then put on a hot plate set at 400 ºC in order to allow for water evaporation. 3 ml phenol solution (2,4-disulfonic acid) was added to the dry samples after cooling. 15 ml of distilled water was then added to the samples to dissolve and dilute the acid. There was a colour change to light purple and heat was generated. 6N ammonium hydroxide was then added to the sample until a yellow colour was developed. The samples were put into test tubes which was then placed in the colorimeter to determine the absorbance. The absorbance of nitrate standard solution was also determined. The concentration of nitrate in the samples was then determined using Equation (4).

$$y = \frac{\sum Q}{5} \times \frac{100\ \text{ml}}{25\ \text{ml}} \quad (4)$$

Where $Q = \frac{\text{concentration of standards}}{\text{absorbance of standards}}$ and y = concentration of standard.
The value of y was multiplied with the absorbance of each sample.

2.1.7. Sulphates

Colorimetric Method was used by measuring 10 ml of each sample into 25 ml volumetric flasks. 1 ml of Gelatin solution was measured into the samples. Distilled water was then added until the sample in the volumetric flask was filled after which it was left for some time to allow colour to develop. The sample became viscous when a whitish colour was developed. The samples were poured into the test tube after a few minutes and compared to the prepared sulphate standards. The standards and samples were then put into test tubes to determine their absorbance using the colorimeter. The concentration of each sample was calculated using Equation (5).

$$y = \frac{\sum Q}{5} \times \frac{25\ ml}{10\ ml} \text{ (Heydari and Bidgoli, 2012; Ojok et al., 2017)} \quad (5)$$

Where $Q = \frac{\text{concentration of standards}}{\text{absorbance of standards}}$ and y = concentration of standard.
The value of y was multiplied with the absorbance of each sample.

2.2. Heavy metals

Atomic Adsorption Spectrometric method was used to determine heavy metals present in the samples. This method allows rays of light to pass through an instrument that generates, examines or records spectra. An absorption spectrometer was used to determine the spectrum created by an unknown substance. The instrument's lenses focuses the light while a central prism splits the light into a spectrum of its constituent colours. The colours appearing on the screen represents the wavelengths that the sample did not absorb.

3. Results and discussion

The conductivity was observed to increase along the treatment units. This is due to the addition of chemicals in the coagulation and disinfection processes. These chemicals release ions into the water as dissolved elements. Table 1 shows the conductivity of water samples along the treatment units.
The temperature of the water samples remained fairly constant, ranging from 26.0 ºC to 30.0 ºC, along the treatment units.
Table 2 shows the results of pH, turbidity and colour along the treatment units. The pH was observed to increase to near neutral after the disinfection process. Turbidity was observed to reduce significantly after sedimentation due to removal of suspended particles at the filtration unit.
The colour concentration of the water samples was observed to increase along the treatment units due to the application of chemicals during the treatment process.

Table 1: Conductivity of Water Samples

Water Samples	Conductivity (µS/cm)			
	Week 1		Week 2	
	Morning	Afternoon	Morning	Afternoon
Distilled water	2.00	2.00	2.00	2.00
Aeration unit	188.00	188.33	187.33	188.00
After sedimentation	197.00	198.00	192.67	197.33
After filtration	199.33	199.00	193.67	199.00
After disinfection	200.33	201.00	194.33	201.00
Backwash water	207.67	207.00	201.67	207.67
Tap water	197.67	197.00	166.67	198.00

Table 2: Turbidity, pH Value and Colour along Treatment Units

Water Samples	pH value		Turbidity (mg/l)		Colour (mg/l)	
	Week 1	Week 2	Week 1	Week 2	Week 1	Week 2
Aeration unit	6.45	6.46	5.50	7.00	126.00	140.00
After sedimentation	6.15	6.46	2.00	2.00	39.00	53.50
After filtration	6.29	6.71	0.00	0.00	53.50	39.00
After disinfection	6.83	6.73	0.00	0.00	68.00	68.00
Backwash water	6.54	7.00	0.00	0.00	39.00	39.00
Tap water	6.30	7.02	0.00	0.00	10.00	24.5

3.1. Chemical parameters

Table 3 shows chloride, nitrate and sulphate to be within the required limit recommended by the World Health Organization. It is seen from the table that the concentration of chloride reduces after the coagulation unit. This was due to the metallic alum added which ionized into Al^{3+} ion, which may react with chloride in the water to form a metallic chloride that settled at sedimentation. The level of concentration is almost the same at filtration but there's an obvious increase in concentration levels at disinfection due to the addition of chlorine.
The concentrations of nitrate and sulphate were observed to be extremely low and remained so throughout the treatment units.

Table 3: Concentration of Chloride, Nitrate and Sulphate along Treatment Units

Water Samples	Concentration (mg/l)					
	Chloride		Nitrate		Sulphate	
	Week 1	Week 2	Week 1	Week 2	Week 1	Week 2
Aeration unit	18.31	18.27	0.22	0.25	2.73	2.81
After sedimentation	16.40	17.16	0.27	0.28	4.29	4.22
After filtration	16.40	17.15	0.22	0.23	3.20	3.12
After disinfection	19.07	21.74	0.24	0.24	1.72	1.72
Backwash water	14.53	19.45	0.28	0.27	2.03	2.03
Tap water	12.24	16.01	0.25	0.22	2.73	3.28

3.2. Heavy Metals

Heavy metals such as zinc, copper, lead and cadmium were seen to be low in concentration in the water samples. They reduced significantly along the treatment units. Table 4 shows the concentration of selected heavy metals along treatment the units.

Table 4: Concentration of Selected Heavy Metals along Treatment Units

Water Samples	Concentration (mg/l) Lead		Copper		Zinc		Cadmium	
	Week 1	Week 2	Week 1	Week 2	Week 1	Week 2	Week 1	Week 2
Raw water	9.44	9.41	4.50	4.55	0.07	0.06	1.099	1.098
Settled water	8.58	8.61	2.32	2.30	0.05	0.05	0.869	0.867
Filtered water	0.00	0.00	1.69	1.67	0.02	0.02	0.166	0.163
Treated water	0.00	0.00	0.01	0.08	0.01	0.01	0.071	0.070
Backwash water	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Tap water	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

4. Conclusion

It was observed that the concentrations of zinc, cadmium, lead and copper reduced in quantity from the influent through the various treatment units to the effluent point, i.e. the tap water point at the treatment plant. The concentrations at the effluent point were much lower than the acceptable or required standards in water hence making the water safe for use by humans.

It was also discovered that the chloride concentrations, nitrate levels, pH range and turbidity were within the acceptable water quality standards hence ensuring that the entire community is supplied with adequate quality water in their required quantity. The various units of the treatment plant was observed to function at a high rate of efficiency. This was deduced from the extremely low levels of contaminants present in the raw water sample. The importance of the intake unit cannot be overemphasized since it was seen that it is capable of removing a considerable amount of turbidity in water as can be seen in the closeness of the turbidity result that was observed along the treatment units.

Therefore, it can be said from the results that water supplied from the treatment plant of the Opa waterworks is safe for drinking as far as the level of the contaminants tested is concerned. This goes a long way in keeping the Obafemi Awolowo University community from disease-causing organisms.

It is necessary that further studies be carried out on other contaminants such as hydrocarbons, hydrogen sulphide, nitrites, phosphate and other heavy metals to really ascertain the variance of these contaminants over the treatment units and whether they are above the required or acceptable standards.

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