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Quality Appraisal of Old and New (Greater) Water Works in Makurdi . Benue State Nigeria

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Abstract
The increase in the level of pollution of river Benue due to human activity has necessitated the analysis and the evaluation of treated water at the greater water works in Makurdi to know if the water is really free from hazardous or dangerous chemical pollutants , to prevent water users from infection and water borne diseases and to see if water quality standards are adhered to . The new water works commissioned recently in Makurdi Benue State christened GREATER WATER WORKS is estimated to be …50,000m^3/ day capacity and 3x more than the former old water works which was18,000m^3 /day . The quality of water was done on the raw water from the intake which is River Benue, the old and greater water works . Considering the statistics already existing of the quality of water in the old water works , the following were assessed. Turbidity was assesed from an average value of 450.33 treated to 1.45 FTU in the old water works and 0.28 FTU in the greater water works respectively . Color was treated from an average value of 224 to 2.33 TCU in the old water works and 0. 0 in the greater water works respectively. Among the mineral elements , calcium was treated from an average value of 60mg/l to 20mg/l in both old and greater water works respectively, magnesium was treated from the average of 26.7 to 20mg/l while nitrates were treated from an average value of 38.4 to 8mg/l in old water works and 7mg/l in greater water works respectively. Bacterial load of 1800 in raw water was treated to 1.0 in the old water works and 0.0 in the greater water works. The treatment chemicals were not altered in this new scheme apart from increase in application due to expansion in capacity . Introduction of hrodrocyclone removes sand and gravel while filtration is carried out after aeration in order to remove the iron in water through coagulation . This was not the case in the old water works , these essentials were absent .
Keywords Analysis , Equipment , Filtration ,Greater , Water

Introduction

Water is the most important natural resource in the world, a preliminary report prepared for Department of Water Affairs and Forestry DWAF (2012) addressed salient issues concerning water , the report suggested the embarking upon a process to develop a framework that will set in motion a course of action to ensure that there is sufficient water, in both quantitative and qualitative terms, to support South Africa's path of growth and development . From records of Beetseh and Num (2013) Makurdi. is Located in Nigeria . (7°43′50″N 8°32′10″E) The river- Benue divides the city into south and north , the water works is situated on the south bank of the river .

Figure 1 Water is the most plentiful compound on Earth and is essential to life. Courtesy Britannica Encyclopedia 2010

WHO/ Water Supply, Sanitation and Hygiene Development records show that around 1.1 billion people globally do not have access to improved water supply sources where as 2.4 billion people do not have access to any type of improved sanitation facility. About 2 million people die every year due to diarrheal diseases, most of them are children less than 5 years of age. The most affected are the populations in developing countries, living in extreme conditions of poverty, normally peri-urban dwellers or rural inhabitants. An international day to bring attention on the importance of freshwater and the need for its sustainable management was recommended at the 1992 United Nations Conference on Environment and Development (UNCED). The United Nations General Assembly then designated 22 March 1993 as the first World Water Day and has remained so till date. In South Africa there must be sufficient water for the country to achieve its 6% economic growth target ,at the same time, every person must have access to potable water. These two goals must be achieved by not compromising the ecological sustainability of the resource. The Department has also embarked upon rigorous water assessment studies referred to as Reconciliation Strategies in order to achieve the reconciliation of supply and demand for both water scarce areas as well as those experiencing relatively high levels of demand. These strategies aim to ensure the supply of water at adequate levels of assurance within the constraints of affordability and appropriate levels of service to users and protection of current and possible future water resources. Apart from ensuring water availability for growth purposes, the Department is very mindful of water use behaviour that impacts negatively on both water resource quantity and quality. It is currently exploring a potential mix of mechanisms to change this behaviour, which include regulatory instruments, market-based instruments, self-regulation, and awareness and education, and it will match appropriate mechanisms to mitigate offending behaviour.

In Nigeria the responsibility of improved water supply is assumed by government at the Federal and State levels through its boards ,corporations and river basins. However , since financing has become the fundamental issue, most water projects-Development Authorities are funded by large conglomerates. The African Development Bank is carrying out Water Schemes Of Taraba And Oyo States [Urban Water Supply And Sanitation For Oyo And Taraba States March 2009.] Among the objectives of the project are high priority on the development of safe and adequate water supply and sanitation services as a key instrument for fighting poverty and accelerating socio-economic development in the National Economic Empowerment and Development Strategy (NEEDS) and State Economic Empowerment and Development Strategy (SEEDS). The current low level access to clean water and safe sanitation across the country has affected the health and living condition of the population, particularly the urban poor population. The two states Oyo and Taraba were selected based on the very low water coverage (approximately 30%) and their commitments to improve the provision of water and sanitation service to their inhabitants . The majority of the beneficiary population , about 70%, live in areas that are poorly served by modern water and sanitation infrastructure. The estimated cost of the project is UA 58.82 million, and will be financed from an ADF loan of UA 50 million, Oyo State Contribution of UA 6.45 million and Taraba State contribution of UA 2.37 million and implementation will last five years. The project will improve public health and standard of living in the cities and surroundings, increase the investment and operational conditions for industrial and commercial activities, thereby enhancing opportunities for employment . The National Water Policy lays emphasis on the introduction of reforms, especially PPP, to increase investment in the sector, improve operational standards and the commercial viability of services in the sector. In Makurdi Benue State , sources of water include the River Benue – a large body of water with capacity to cater for the water needs of over five cities together. River Benue passes through the metropolis and is accessible on all sides. . Most inhabitants of the city fetch direct from the River, the State Government through its water Ministry operates a water treatment plant which uptakes water for treatment. This water is however not enough for the end users because the capacity of the treatment plant is far below the requirement needs of the people. There are therefore bore holes and hand dug wells also known as tube wells as alternative water sources. Water hawkers are seen all over the metropolis carrying water in 20 litre containers packed in hand driven trucks for sale. The Greater Water Works recently commissioned has capacity of 50000M^3 /day which is 4 times higher than the old water works. Naturally the intake of water correspondingly is higher. Considering the demand for potable water and the need to achieve globally accepted goals , assessing the quality of this water becomes imminent.

1 . 0 Water Use

Water use or demand is expressed numerically by average daily consumption per capita (per person). In the United States the average is approximately 100 gallons (380 litres) per capita per day for domestic and public needs. Overall the average total demand is about 180 gallons (680 litres) per capita per day, when commercial and industrial water uses are included. (These figures do not include withdrawals from freshwater sources for such purposes as crop irrigation or cooling operations at electric power-generating facilities.) Water consumption in some developing countries may average as little as 4 gallons (15 litres) per capita per day. The world average is estimated to be approximately 16 gallons (60 litres) per person per day.

In any community, water demand varies on a seasonal, daily, and hourly basis. On a hot summer day, for example, it is not unusual for total water consumption to be as much as 200 percent of the average demand. The peak demands in residential areas usually occur in the morning and early evening hours (just before and after the normal workday). Water demands in commercial and industrial districts, though, are usually uniform during the working day. Minimum water demands typically occur in the very early or predawn morning hours. Civil and environmental engineers must carefully study each community's water use patterns in order to design efficient pumping and distribution systems.

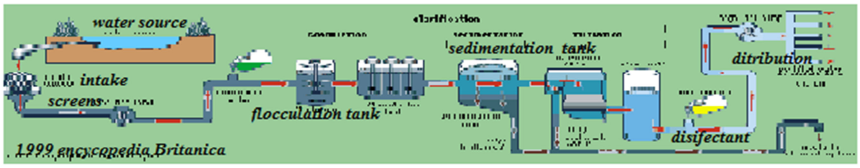

Figure 2 Water from inlets located in the water supply, such as a lake, is sent to be mixed, coagulated, and flocculated and is then sent to the waterworks for purification by filtering and chemical treatment. After being treated it is pumped into water mains for storage or distribution.

2. 0 Water Treatment

2 . 1 Clarification

Impurities in water are either dissolved or suspended. The suspended material reduces clarity, and the easiest way to remove it is to rely on gravity. Under quiescent (still) conditions, suspended particles that are denser than water gradually settle to the bottom of a basin or tank. This is called plain sedimentation. Long-term water storage (for more than one month) in reservoirs reduces the amount of suspended sediment and bacteria. Nevertheless, additional clarification is usually needed. In a treatment plant, sedimentation (settling) tanks are built to provide a few hours of storage or detention time as the water slowly flows from tank inlet to outlet. It is impractical to keep water in the tanks for longer periods, because of the large volumes that must be treated. Sedimentation tanks may be rectangular or circular in shape and are typically about 10 feet (3 metres) deep. Several tanks are usually provided and arranged for parallel (side-by-side) operation. Influent (water flowing in) is uniformly distributed as it enters the tank. Clarified effluent (water flowing out) is skimmed from the surface as it flows over special baffles called weirs. The layer of concentrated solids that collects at the bottom of the tank is called sludge. Modern sedimentation tanks are equipped with mechanical scrapers that continuously push the sludge toward a collection hopper, where it is pumped out. The efficiency of a sedimentation tank for removing suspended solids depends more on its surface area than on its depth or volume. A relatively shallow tank with a large surface area will be more effective than a very deep tank that holds the same volume but has a smaller surface area. Most sedimentation tanks, though, are not less than 10 feet deep, in order to provide enough room for a sludge layer and a scraper mechanism. A technique called shallow-depth sedimentation is often applied in modern treatment plants. In this method, several prefabricated units or modules of “tube settlers” are installed near the tops of tanks in order to increase their effective surface area. Suspended particles cannot be removed completely by plain settling. Large, heavy particles settle out readily, but smaller and lighter particles settle very slowly or in some cases do not settle at all. Because of this, the sedimentation step is usually preceded by a chemical process known as coagulation. Chemicals (coagulants) are added to the water to bring the nonsettling particles together into larger, heavier masses of solids called floc. Aluminum sulfate (alum) is the most common coagulant used for water purification. Other chemicals, such as ferric sulfate or sodium aluminate, may also be used. Coagulation is usually accomplished in two stages: rapid mixing and slow mixing. Rapid mixing serves to disperse the coagulants evenly throughout the water and to ensure a complete chemical reaction. Sometimes this is accomplished by adding the chemicals just before the pumps, allowing the pump impellers to do the mixing. Usually, though, a small flash-mix tank provides about one minute of detention time. After the flash mix, a longer period of gentle agitation is needed to promote particle collisions and enhance the growth of floc. This gentle agitation, or slow mixing, is called flocculation; it is accomplished in a tank that provides at least a half hour of detention time. The flocculation tank has wooden paddle-type mixers that slowly rotate on a horizontal motor-driven shaft. After flocculation the water flows into the sedimentation tanks. Some small water treatment plants combine coagulation and sedimentation in a single prefabricated steel unit called a solids-contact tank. Alum ionizes to give positive and negative ion which attract impunities of negative charge and course to precipitates and settle to the bottom making filtrations to become simple.

Action of added lime

$$Ca(OH)_2 \longrightarrow Ca^{2+} + 2OH^-$$

$$Na_2CO_3 \longrightarrow 2Na^+ + CO_3^{2-}$$

The lime reacts with Ca^{2+}, the primary ion causing hardness and precipitates which can be filtered out.

2.2 Filtration

Even after coagulation and flocculation, sedimentation does not remove enough suspended impurities from water to make it crystal clear. The remaining nonsettling floc causes noticeable turbidity in the water and can shield microbes from disinfection. Filtration is a physical process that removes these impurities from water by percolating it downward through a layer or bed of porous, granular material such as sand. Suspended particles become trapped within the pore spaces of the filter media, which also remove harmful protozoa and natural colour. Most surface water supplies require filtration after the coagulation and sedimentation steps. For surface waters with low turbidity and colour, however, a process of direct filtration, which is not preceded by sedimentation, may be used.

Two types of sand filter are in use: slow and rapid. Slow filters require much more surface area than rapid filters and are difficult to clean. Most modern water treatment plants now use rapid dual-media filters following coagulation and sedimentation. A dual-media filter consists of a layer of anthracite coal above a layer of fine sand. The upper layer of coal traps most of the large floc, and the finer sand grains in the lower layer trap smaller impurities. This process is called in-depth filtration, as the impurities are not simply screened out or removed at the surface of the filter bed, as is the case in slow sand filters. In order to enhance in-depth filtration, so-called mixed-media filters are used in some treatment plants. These have a third layer of a fine-grained, dense mineral called garnet at the bottom of the bed. In this new Greater Makurdi Water Works the hydro cyclone is introduced reduce the turbidity by removing sand and gravel , while aeration is also done before filtration to remove iron from the water which coagulates is easily removed.

2.3 Disinfection

Disinfection destroys pathogenic bacteria and is essential to prevent the spread of waterborne disease. Typically the final process in drinking-water treatment, it is accomplished by applying either chlorine, ozone, or ultraviolet radiation to clarified water. The addition of chlorine or chlorine compounds to drinking water is called chlorination. Chlorine compounds may be applied in liquid and solid forms—for instance, liquid sodium hypochlorite or calcium hypochlorite in tablet or granular form. However, the direct application of gaseous chlorine from pressurized steel containers is usually the most economical method for disinfecting large volumes of water. Taste or odour problems are avoided with proper dosages of chlorine at the treatment plant, and a residual concentration can be maintained throughout the distribution system to ensure a safe level at the points of use. Chlorine can combine with certain naturally occurring organic compounds in water to produce chloroform and other potentially harmful by-products. The risk of this is very small, however, when chlorine is applied after coagulation, sedimentation, and filtration. Ozone gas may also be used for disinfection of drinking water. However, since ozone is unstable, it cannot be stored and must be produced on-site, making the process more expensive than chlorination. Ozone has the advantage of not causing taste or odour problems; it leaves no residual in the disinfected water. The lack of an ozone residual, however, makes it difficult to monitor its continued effectiveness as water flows through the distribution system. .Aeration is a physical treatment process used for taste and odour control and for removal of dissolved iron and manganese. It consists of spraying water into the air or cascading it downward through stacks of perforated trays. Dissolved gases that cause tastes and odours are transferred from the water to the air.

The water standing for some time is exposed to oxygen which attack organic matter and hasten oxidation of this toxic organic matter converting them into their harmless form such as carbon(iv)oxide (CO_2).

$$CH_3COOH \longrightarrow CH_4 + CO_2$$

Oxygen from the air, meanwhile, reacts with any iron and manganese in the water, forming a precipitate that is removed by sedimentation and filtration.An effective method for removing dissolved organic substances that cause tastes, odours, or colours is adsorption by activated carbon. Adsorption is the capacity of a solid particle to attract molecules to its surface. Powdered carbon mixed with water can adsorb and hold many different organic impurities. When the carbon is saturated with impurities, it is cleaned or reactivated by heating to a high temperature in a special furnace. Action of added activated carbon

$$2Cl_2 + C_{(s)} + 2H_2O_{(l)} \longrightarrow CO_{2(aq)} + 4H^+ + 4Cl^-_{(aq)}$$

Many communities reduce the incidence of tooth decay in young children by adding sodium fluoride or other fluorine compounds to filtered water. The dosage of fluoride must be carefully controlled. Low concentrations are beneficial and cause no harmful side effects, but very high concentrations of fluoride may cause discoloration of tooth enamel.

3 .0 Materials used

Thermometer , Hach direct reading spectrophotometer model Dr 2000 Lovibond 200 apparatus , manver hardness indicator sterile jericans – used for collection of water samples , Hanna digital PH meter Dissolved oxygen (DO_2)meter model 9071 for determining the dissolving oxygen , Sample bottles, autoclave, Macconkey

broth, beakers, conical flask, and measuring cylinder for total coliform bacteria .
Rubber container were used to collect the water sample from the three location including treated water from both the old and the new plants and raw water. The containers used for collection of water sample were washed with detergent first, rinsed with distilled water, and each container was labelled. The samples were then collected directly from the source. In doing so, the temperature of the samples was determined during the collection of the samples. The temperature was determined using a thermometer. Also the pH of the water samples was determined. 3 samples were collected each at the processed stages of makurdi water works, namely; raw water, treated water in old plant and treated water in new plant. Samples were analysed in the Benue State water board central laboratory immediately after collection.

4.1 Determination of turbidity

The program number (750) for turbidity was entered and the wavelength was adjusted to 450nm and the fill unit was display. A blank of 25ml of deionised water was measured into the sample and placed into the cell holder. The light shield was closed. The zero key was pressed and the reading display 0.00 fill units. The blank was then removed, 25ml of water was measured using the sample cell bottle and placed into the light shield then closed. The read/enter key was pressed and the reading display fill unit and recorded. This procedure was repeated for all the water samples

4.2 Determination of colour

Direct reading spectrophotometer (Dr/2000) from HATCH company was used. The program number (120) for colour was entered and the wavelength was adjusted to 455nm and he unit ptco colour was displayed. A blank of 25ml of deionized water was measured into the sample cell and placed into the cell holder. The light shield was closed. The zero key was pressed, and the reading display 0.00ptco colour unit. The blank was then removed, 25ml of water sample was measured using the sample cell bottle and placed into the light shield then closed. The read/enter key was pressed and the reading displayed ptco colour unit and recorded. This procedure was repeated for all the water samples.

4.3 Determination of Total Hardness

The hardness test kit model HA-4P-MG-L was used. 5ml of water sample was measured using a plastic tube and poured into the mixing missing bottle. 3 drops of buffer hardness one solution was added and swirled to mix. I drop of manver hardness indicator solution was added. EDTA titrant was added drop by drop into the mixing bottle and mixture swirled to allow for uniform mixing as each drop of the drop of the EDTA solution was added until the mixture colour changes from pinked to blued. The hardness in mgl^- as calcium carbonate ($CaCo_3$) was calculated by multiplying the number of drops added by a factor of 20.

4.4 Determination of Calcium Hardness

The plastic tube was level filled with water to be tested and the content poured into the mixing bottle. 2 drops 8m potassium hydroxide solution was added. One calver 2 calcium indicator powder pillow was added and titrated with EDTA by adding drop-wise until the pink colour of the mixture was changed to blue. The calcium hardness in mgl^- was calculated to be equal to the number of EDTA added multiply by a factor of 20.

4.5 Determination of Magnesium hardness.

This was calculated by subtracting the calcium hardness value from total hardness value.

4.6 Determination of Total Iron

The ferrover powder pillow method was adopted. The program number (250) for iron was entered and the wavelength was adjusted to 510nm and the mgl^{-1}fe was display. A blank of 25ml of deionized water was measured into the sample cell and placed into the cell holder. The light shield was closed. The zero key was pressed, and the reading display 0.00mgl^{-1}fe. The blank was then removed, 25ml of water sample was measured using the sample cell bottle and one ferrover iron reagent powder pillow was added and allowed to stand for one minute reaction period, after which it was placed into the cell holder. The read/enter key was pressed and the reading was display and recorded. This procedure was repeated for all the water sample.

4.7 Determination of Chromium (Cr^{+6}).

The 1,5 – diphenylhydrazide method was adopted. The program number (90) for iron was entered and the wavelength was adjusted to 540nm and the $mgl^{-1}Cr^{+6}$ was display. A blank of 25ml of deionised water was measured into the sample cell and placed into the holder. The light shield was closed. The zero key was presses, and the sample cell bottle and one chromaver 3 reagent powder pillow was added and allowed to stand for one minute reaction period, after which it was placed into the cell holder. The read/enter key was pressed and the reading display $mgl^{-1}Cr^{+6}$ and recorded. This procedure was repeated for all the water samples.

4.8 Determination of Zinc in Water.

The program number (790) for zinc in the water was entered and the wavelength was adjusted to 620nm, the unit ppm Zn was adjusted. A 30ml plastic beaker was filled to the 10ml mark with deionised water. 5ml of 1:1 hydrochloric acid was added and a 50ml cylinder was placed under the outlet tube. The solution in the beaker was transferred to setup column why the solution that passes through was discarded. 10ml of 0.1hydrochloric acid extracted was measured into a 30ml plastic beaker, 5.0ml of 1:1 Hcl was added. The content of the mixture was pour into the syringe of the apparatus and 5.0ml of 1:1 Hcl was again added. 20ml of 0.2m sodium sulphate solution was added. The filtrate was phenolphthalein indicator was added. 5ml of sodium hydroxide was added drop –wise until the appearance of a pink colour. The solution was dilutes with deionized water to 50ml mark. The PH of the solution was adjusted 9.0 by adding NaOH solution. One zinc cover v zinc reagent was powder pillow was and the mixture inverted several times until all the particles have dissolved. The solution was divided into half and 25ml of solution was pour into it's sample cell 1.0ml cyclohexanone was added and the solution of the solution was shake for 30seconds. The mixture was allowed to stand for 5minutes. Meanwhile, 25ml of deionized water was measured into the sample cell and placed into the cell holder, the light shielded was closed. And zero key was pressed, and the reading displayed 0.00ppmzn. the blank was then removed and the read/enter key pressed. The concentration of zinc in the sample was displayed on the screen and then recorded.

4.9 Determination of pH

The PH meter from the Hanna company was switched on and the probe immerged into the water sample. The reading displayed was recorded at it's stabilised.

4.10 Determination of Sulphate

Sulfaver 4 method (powder pillow) was adopted. The program number (580) for sulphate was entered and the wavelength was adjusted to 450nm and the

$Mgl^{-1}S0_4^{2-}$ was displayed. A blank of 25ml of deionized was measured into the sample cell and placed into the cell holder. The light shield was closed. The zero was pressed, and the reading displayed $0.00mgl^{-1}$ $S0_4^{2-}$. The blank was then removed, 25ml of water sample was measured using the sample cell bottle and one suffaver 4 sulphate reagent was added to and allowed to stand for five minutes reaction period, after which it was place into the cell holder. The read/enter key was passed and the reading displayed $mgl^{-}S0_4$ and recorded. This procedure was repeated for all the water samples.

4.11 Determination of Phosphate

The phosver 3 method was used. The program number [490] for phosphate was entered and the wavelength was adjusted to 890nm and the $mgl^{-1}po_4^{-3}$ was displayed. A blank of 25ml of deionised water was measured into the sample cell and placed into the cell holder. The light shield was closed. The zero key was pressed, and the reading displayed $0.00mgL^{-1}PO_4^{-3}$. The blank was then removed; 25ml of the water sample was measured using the sample cell bottle and one phosver 3 phosphate pillow was added to and allowed to stand for two minutes (2mins) reaction period, after which it was placed into the cell holder. The read/enter key was pressed, and the reading displayed mgl^{-1} PO_4^{-3} and recorded. This procedure was repeated for all the water samples.

4.12 Determination of Nitrate

The sulfaver 4 method (powder pillow) was adopted. The programme number (355) for sulphate was entered and the wavelength was adjusted to 500nm and the mgL^{-1} NO_3^- was displayed. A blank of 25ml of deionised water was measured into the sample cell and placed into the cell holder. The light shield was closed. The zero key was pressed, and reading displayed $0.00mgL^{-1}$ NO_3^-. The blank was then removed, 2ml of water sample was measured using the sample cell bottle and one Nitriver 5 Nitrate powder pillow was added and allowed to stand for 1min. reaction period, after which it was placed into a cell holder. The read/enter key was pressed and the reading displayed mgL^{-1} NO_3^- and recorded. The procedure was repeated for all the water samples.

4.13 Residual Chlorine

10ml of water sample was measured into 10ml bottle. Two drops of O-tolidine were added and inserted into the lovibond 200 apparatus for residual chlorine in mg/l

4.14 Determination of Total Solids.

Total solids was calculated from the addition of suspended solids and total dissolved solids .

4.15 Determination of Total Coli-form Bacteria

10ml of maCconkey broth was filled in 15 bottles using sterile syringe. The inverted Durham tubes were inserted in each of the bottles and the autoclaved for 15minutes at 121°C. the bottle were then removed and placed in a sterile environment . 10ml of the water samples was inoculated in the first five bottles . 1ml of water was inoculated in the second five bottles while 0.1ml of water was inoculated into the last five bottles. The bottles were kept in an incubator and observed at the end of 24 and 48hoursfor presumptive and confirmatory test respectively . the number of positive bottles indicated by colour and gas formation in each of the rolls were recorded and compared with the bacterial load in a MaCconkey table. This procedure was repeated for all the water samples (ODNWRI, 1997),

4.16 Determination of Dissolves Oxygen

The dissolved oxygen meter (model 9071 made by the HACH company) was used. The meter was switch on and the probe immerge into distilled water to rinse and adjust the value to zero reading. The probe was then immerged into the water samples and the reading was recorded. The procedure was repeated for all the water samples.

5.0 Results

A→ Raw water source
B→ Treated water from old water works
C→ Treated water from new water works

	A1	A2	A3	AX	B1	B2	B3	BX	C1	C2	C3	CX
Turbidity	115	1120	116	450.33	1.46	1.46	1.44	1.45	0.29	0.30	0.26	0.28
Colour	224	230	218	224	2	3	2	2.33	0	0	0	0
Odour	Unobjectionable	Unobjectionable	Unobjectionable	Unobjectionable								
Taste	Unobjectionable	Unobjectionable	Unobjectionable	Unobjectionable								
Hardness	100	80	80	86.67	40	40	40	40	40	40	40	40
Ca	60	60	60	60	20	20	20	20	20	20	20	20
Mg	40	20	20	26.7	20	20	20	20	20	20	20	20
Fe^{2+}	3.42	3.14	3.34	3.3	0.20	0.18	0.17	0.18	0.08	0.07	0.08	0.07
Cr^{6+}	0.3	0.3	0.3	0.3	0.02	0.02	0.02	0.02	0.01	0.01	0.01	0.01
Mn^{2+}	0.3	0.3	0.3	0.3	0.025	0'025	0.025	0.025	0.0	0.01	0.00	0.003
Cu^{2+}	1.34	1.30	1.40	1.35	0.48	0.44	0.48	0.46	0.22	0.20	0.18	0.20
PH	7.20	7.20	7.20	7.20	6.90	6.80	6.90	6.86	7.0	6.9	7.00	6.97
$S0_4^{2-}$	45	50	44	46.3	24	18	20	20.7	13	10	10	11
$P0_4^{3-}$	1.23	1.33	1.24	1.27	0.24	0.30	0.26	0.27	0.20	0.22	0.19	0.20
$N0_3^-$	38.6	40.1	36.4	38,4	9.4	8.6	8.8	8.9	7.6	7.8	7.4	7.6
NO_2	0.3	0.3	0.4	0.33	0.1	0.1	0.1	0.1	0.10	0.1	0.1	0.1
COD	168	172	160	166.7	44	40	44	42.7	38	40	42	40
Zn^{2+}	2.46	2.38	2.44	2.43	0.54	0.48	0.46	0.49	0.26	0.22	0.20	0.23
DO1	5.5	5.4	5.5	5.5	5.6	5.6	5.5	5.6	5.8	5.7	5.7	5.7
DO_2(S)	4.0	4.0	4.2	4.06	5.2	5.2	5.1	5.16	5.5	5.4	5.4	5.4
Bacterial	71800	1800	1800	25133.3	1	2	0	1	0	0	0	0
Residual Cl_2	0.00	0.00	0.00	0.00	0.15	0.15	0.20	0.06	0.25	0.20	0.25	0.23
Suspended solids	64	61	63	62.67	8	8	8	8	4	3	2	3
Total Dissolve solids	32.0	30.0	30.6	30.87	12.2	10.2	10.2	10.87	5.20	4.20	4.0	4.47
BOD	84	86	80	83.3	22	20	22	21.3	19	20	21	20
Total solid	99	98	90	95.67	19.3	18.2	16.8	18.1	9.0	6.2	6.6	7.27

6 . 0 Observations and discussions

The samples of water analysed for treatment in table 5 . 0 shows that the treated water contain 0.48mg/l and 0.20mg/l of Cu, 0.49mg/l and 0.23mg/l of Zn, 0.18mg/l and 0.07mg/l of Fb, 0.02mg/l and 0.01mg/l of Cr,0.025mg/l and 0.003mg/lof Mn. All the results analyzed for finished product of treated water fall within the same range given by world health organization (WHO) standards

From the results obtained above, treated water of finished products from old and new Makurdi water works met the world health organization (WHO), 2004 drinking water quality standard for all the parameters..

Comparing the results in table **5 . 0** with each other that is old and new water works treated and with the standard set by WHO in 2004 for portable water

7 . 0 Conclusion

The treatment of water has shown from results very clear potable water yet from experience there are several factors that may affect the quality of water produced from Makurdi Water Works. They are , under dosing and over dosing of chemicals , inability to frequently backwash the filter and sedimentation unit , irregular cleaning and improper handling of water by the water vendors and poor attitude of people toward public water facilities like breaking of pipes . Five general types of impurities are of public health concern. These are organic chemicals, inorganic chemicals, turbidity, microorganisms, and radioactive substances. Organic contaminants include various pesticides, industrial solvents, and trihalomethanes such as chloroform. Inorganic contaminants of major concern include arsenic, nitrate, fluoride, and toxic metals such as lead and mercury. All these substances can harm human health when present above certain concentrations in drinking water. Turbidity also interferes with disinfection by creating a possible shield for pathogenic organisms. The most important microbiological measure of drinking-water quality is a group of bacteria called coliforms. Coliform bacteria normally are not pathogenic, but they are always present in the intestinal tract of humans and are excreted in very large numbers with human waste. Water contaminated with human waste always contains coliforms, and it is also likely to contain pathogens excreted by infected individuals in the community. Since it is easier to test for the presence of coliforms rather than for specific types of pathogens, coliforms are used as indicator organisms for measuring the biological quality of water. If coliforms are not found in the water, it can be assumed that the water is also free of pathogens from above results. The coliform count thus reflects the chance of pathogens being present; the lower the coliform count, the less likely it is that pathogens are in the water. Colour in water may be caused by decaying leaves or algae, giving it a brownish yellow hue. Taste and odour may be caused by naturally occurring dissolved organics or gases. Some well-water supplies, for example, have a rotten-egg odour caused by hydrogen sulfide gas. Chemical impurities associated with the aesthetic quality of drinking water include iron, manganese, copper, zinc, and chloride. Dissolved metals impart a bitter taste to water and may stain laundry and plumbing fixtures. Excessive chlorides give the water an objectionable salty taste. Another parameter of water quality is hardness. This is a term used to describe the effect of dissolved minerals (mostly calcium and magnesium). Minerals cause deposits of scale in hot water pipes, and they also interfere with the lathering action of soap. Hard water does not harm human health, but the economic problems it causes make it objectionable to most people. Water quality standards set limits on the concentrations of impurities allowed in water. Standards also affect the selection of raw water sources and the choice of treatment processes. . Drinking-water regulations include two types of standards: primary and secondary. Primary standards are designed to protect public health, whereas secondary standards are based on aesthetic factors rather than on health effects. Primary standards specify maximum contaminant levels for many chemical, microbiological, and radiological parameters of water quality. They reflect the best available scientific and engineering judgment and take into account exposure from other sources in the environment and from foods. Turbidity is also included in the primary standards because of its tendency to interfere with disinfection. Secondary standards are guidelines or suggested maximum levels of colour, taste, odour, hardness, corrosiveness, and certain other factors

8 0 Recommendations

i. The chemicals used for treating water should always be made available and of good quality.
ii. The rehabilitation work should be properly supervised to ensure quality work.
iii. There should be regular back washing of the filters and sedimentation unit to ensure quality water.
iv. The organization requires more qualified hands .
v. The quality control department should be given proper attention by providing more testing equipments and reagents.
vi. There should be regular workshops to train workers on the new developments in water purification.

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References

^ Preliminary population scenario updates prepared for DWAF by Kayamandi DevelopmentServices (Pty) Ltd March 31, 2012
^ a b Braun, Charles L.; Sergei N. Smirnov (1993). "Why is water blue?". J. Chem. Educ. **70** (8): 612. Bibcode 1993JChEd..70..612B. doi:10.1021/ed070p612.
^ a b Vienna Standard Mean Ocean Water (VSMOW), used for calibration, melts at 273.1500089(10) K (0.000089(10) °C, and boils at 373.1339 K (99.9839 °C). Other isotopic compositions melt or boil at slightly different temperatures.
^ United Nations. Un.org (2005-03-22). Retrieved on 2011-11-22.
^ Re: What percentage of the human body is composed of water? Jeffrey Utz, M.D., The MadSci Network
^ "All About: Water and Health". CNN. December 18, 2007.
^Barzilay, Joshua and others. 'The water we drink " Rutgers University press 1999.
^Ball ,Philip 'Life's Matrix' A biography of water 2000.
^ Community Water and Sanitation Agency (CWSA) (August 2004).
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^ Copyright © Eutech Instruments Pte Ltd 1999
^ DeZuane, John Handbook of Drinking Water Quality (2nd ed.). (1997).
^ "Guidance for Water Quality-Based Decisions: The TMDL Process."
^ Doc. No. EPA 440/4-91-001. April 1991.
^ Boyd, Claude E. Water Quality: (1999).
^Ghana Water Company Ltd. (GWCL 2012).
^Guidelines for Water Reuse US EPA Office of Technology Transfer and Regulatory Support. EPA/625/R-92/004 September 1992
^Groupe de la Banque africaine de développement 2012
^Gumisai Mutume { 2004).
^Gennaccaro, McLaughlin, Betancourt, Huffman and Rose, Infectious Cryptosporidium parvum Oocysts in Final Reclaimed Effluent, Dept Marine Science, U of South Florida, St Petersburg, Florida.
^ EPA Guidelines for Water Reuse, (1996)
^ GE Murray, RS Tobin, B Junkins, DJ Kushner,(1984) Effect of Chlorination on antibiotic resistance profiles of sewage-related bacteria, Appl Environ Microbiol:48(1): 73-74. July 1998
^ Matthew Wook Chang, Freshteh Toghrol, William Bentley, Toxicogenomic Response to Chlorination Includes Induction of Major Virulence Genes in Staphylococcus aureus,Environ. Sci. Technol., 41(21)7570-7575.
^Gennaccaro, McLaughlin, Betancourt, Huffman and Rose, Infectious Cryptosporidium parvum Oocysts in Final Reclaimed Effluent, Dept Marine Science, U of South Florida, St Petersburg, Florida.
^ EPA Guidelines for Water Reuse, (1996)
^ GE Murray, RS Tobin, B Junkins, DJ KushnerEffect of Chlorination on antibiotic resistance profiles of sewage-related bacteria, Appl Environ Microbiol. July 1998:48(1): 73-74,(1984)
^ Matthew Wook Chang, Freshteh Toghrol, William Bentley, Toxicogenomic Response to Chlorination Includes Induction of Major Virulence Genes in Staphylococcus aureus,Environ. Sci. Technol., 41(21)7570-7575.
^ Amy PrudenAntibiotic Resistance genes as emerging contaminants, Studies in Northern Colorado, Environmental Science Technology 40, 7445-7450, 2006,
^Timothy Lapara, Sara Firl,(2006) The Importance of Municipal Sewage Treatment in the Spread of Antibiotic resistance,100th General Meeting of the American Society for Microbiology,. Orlando Fl. May 21–25, 2006
^ Amy Pruden, 2006, Antibiotic Resistance genes as emerging contaminants, Studies in NorthernColorado, Environmental Science Technology 40, 7445-7450
^ Edo Mcgowan, The Watchers.US/edo_politics-reclaimed-water.html-74k(2008)
^ Maria Burke (2004),UK to tackle Endocrine Disruptors in Wastewater, TechnologyNews,September 1, 2004.
^Kingsley Adegboye Vanguard· In Environment 2011
^ Melanie Lidman "Wastewater wonders". Jerusalem Post. 6 August 2010.
^Ms. Payden Email: payden@searo.who.int 2012
^ NEWater FAQ, accessed 8 January 2007.
^Maison de la Chimie Foundation 2004