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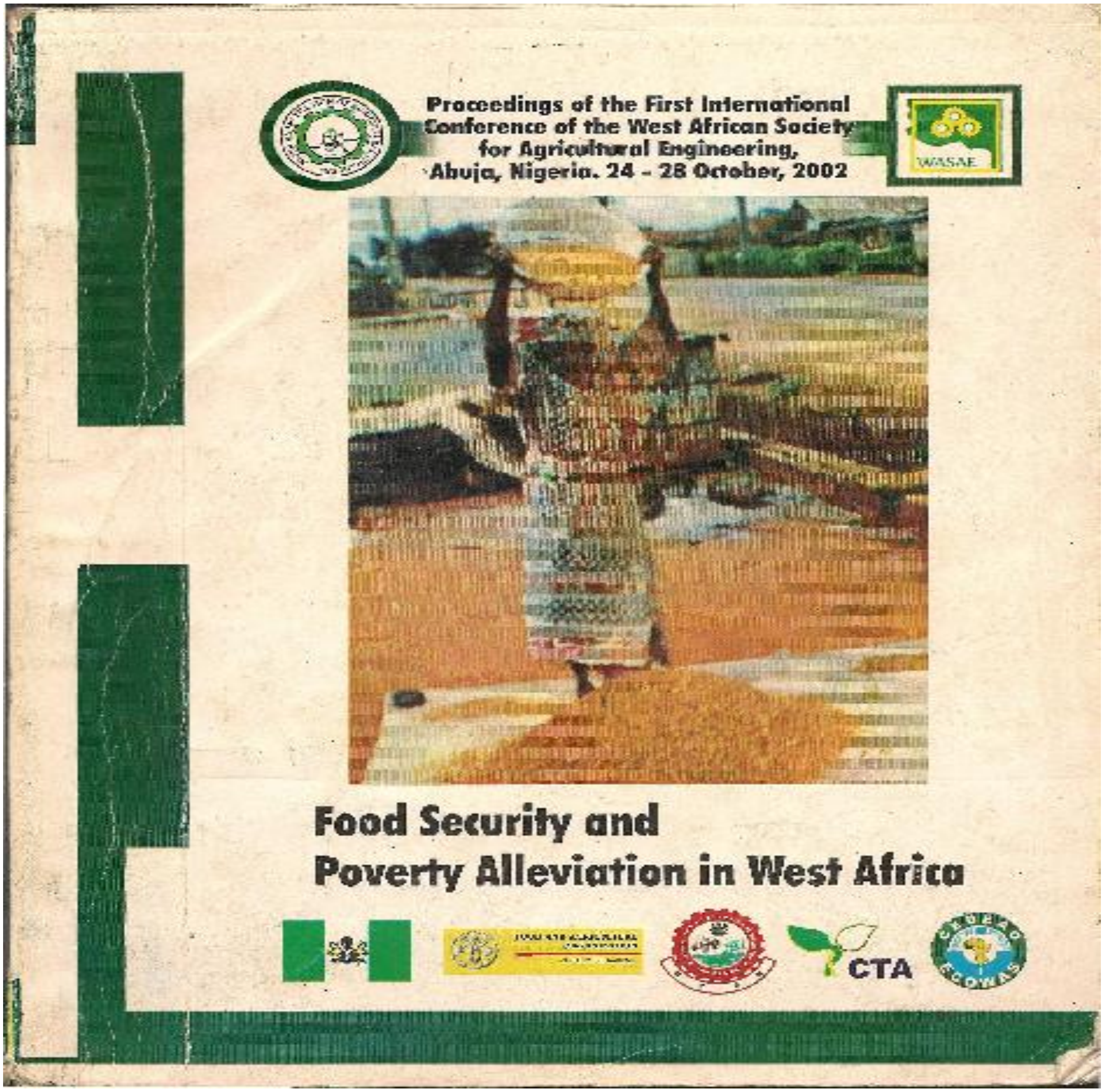

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# DEVELOPMENT OF A MINIWATER TREATMENT PLANT

Olayanju T. M. A. O. J. Omowumi B. A. Dada and I. B. Bashir.
Federal Institute of Industrial Research Oshodi, (FIIRO) Lagos.

## ABSTRACT

*Three raw water samples from Adiyan stream, Matogun stream and Legun river of the Oke – Aro farmstead in Ifo Local Government Area of Ogun State were collected for analyses. The results were to serve as basis for developing a mini water treatment plant.*

*The results of the analysis for Legun river revealed a high pH and turbidity values of 7.2 and 4.1 respectively. The respective values for Adiyan and Matogun streams are 5.5 and 1.0; 5.6 and 0.5*

*A – mini water treatment plant consisting of a flocculation, sedimentation, filtration and disinfecting units was developed based on the results of the analyses The flocculation and sedimentation units are combined. The filtration and disinfecting units are also combined in an equipment that has 3 columns made of stainless steel pipes enclosing activated carbons and candle impregnated with silver ion. The average capacity of the plant is 1000litres per hour*

*The treatment of the water samples in the plant brought the values within the World Health Organisation acceptable level.*

**KEYWORDS**: Development, Miniwater, Rainwater, Treatment,

## INTRODUCTION

Raw water often contains water borne diseases, iron and other impurities, which are injurious to health. In the past few years, for instance, many Nigerians have died as a result of water – borne diseases notably typhoid, fever, cholera and guinea worm. This tends to worsen by day.

A recent study by World Bank confirms that about 36% Nigerians have no access to potable water from the public system (Godwin, 1998). To worsen matters, there are very few water bottling companies in the country whose combined total output is still a far cry from the estimated annual demand (Sonola, 1996). For instance, per capital water consumption rate in most urban cetres of the country is between 50 to 80litres per day as against the 120 litres per day recommended by the World Health Organisation (Agubas, 1998). The establishment of mini-water treatment outlets is therefore imperative for the populace to augment the existing source of potable water supply.

According to Monscvitz et. al. 1978 and Hudson, 1981, four major methods of water treatment are widely practiced. These include the activated carbon process, the reverse osmosis proceeds, the distillation process and the chemical process. A typical water treatment flow process is shown in Figure 1.

Basically, water treatment procedure consists of sedimentation, sometimes followed by coagulation with chemicals and finally filtration. In any effective water treatment process, filtration process remains prominent, since the process generally involves the partial or complete removal of impurities, by passing the water through layer of porous media. The main objective of this work is to develop through laboratory analysis, process technology and equipment suitable for the production of potable water from rivers and streams.

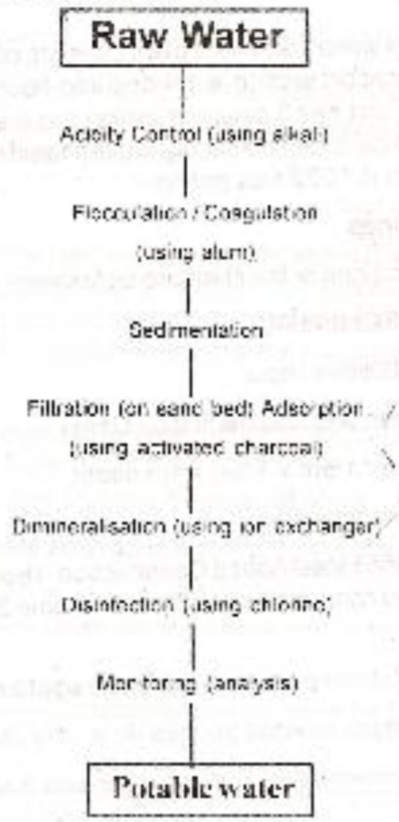


Figure 1. **A Typical Water Treatment Unit Operation**

## MATERIALS AND METHODS

### Raw Water Analysis

Three raw water samples were collected from different sources namely Adiyan stream, Matogun stream and Legun river, all of the Oke – Aro farmstead in Ifo Local Government Area of Ogun State. Using the acceptable sampling technique, three samples each of the raw water were chemically analyzed (Table 1). In order to treat the river water (being the one with worse condition), a mini water treatment plant was developed.

### Plant Description

The developed mini water treatment plant consists of a clarification and filtration section. The clarification section is divided into flocculation and sedimentation units. The filtration unit has 3 columns, which are made of stainless steel pipes enclosing activated carbons and candle impregnated with silver ion. The average capacity of the plant is 1000litres per hour.

### Design Specifications

The design specifications of the plant are as follows:

Plant type FIIROMINIPAC

Flow rate 1000litres / hour

**Clarifier** (Flocculation and Sedimentation Units)

Number / Size One / 1.5m x 1.5m x 1m depth

Type Horizontal flow

Materials of Galvanised steel ribbed Construction sheets on ring beam site wielded on reinforced concrete base Effective volume 2.25m³ (0.25m³ floc + 2.0m³ settlement)

Inlet arrangement Multiple pipe, near surface, radial axis.

Sludge removal Multiple inverted troughs, from end channel in R.C base

Flocculation unit Stainless steel vertical shaft with 3 special blades suspended from a gearbox

Flocculation drive 1 – hp reduction gear electric motor

Outlet arrangement Perforated submerged tubes for clarified water draw – off

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Overflows Two fabricated mild steel weir slot overflow hoopers and two external down pipes to sludge drain channels.

Dividing curtain 1 PVC impregnated nylon fabric sheet with eyelets and suspension cords, to form flocculation compartment.

**Filter** (Filtration and Disinfecting Units)

Number and Size 3 columns

Height - 50cm

Radius – 10cm

Volume – 0.0157m³

Materials of construction: 3mm thick stainless steelConnecting hose with clipping device. Internal materials Sieve, granular activated carbon, granular activated carbon impregnated with silver ions

**Raw Water Treatment**

Eight – 500ml samples of the river water (being the one with worse condition) were each treated with varing concentration of alum (0 – 80ppm). The solutions were stirred for 10minutes and allowed to stand for about 40minutes in an undistubed place before filtration. The treated samples were analysed for pH, turbidity and conductivity (Table 2)

A simple Jar test was carried out to determine the optimal pH for the river water using pH range of 4 - 8 (Table 3). In order to increase the acidity, 1N $H_2SO_4$ was used, while 0.1% $Na_2OH$ was used to increase alkalinity

Five different methods were employed in treating the Legun river water sample. The methods are as follows.

Sample A - River water——Coagulation (Alum) ——Sedimentation ——Decanting.

Sample B - River water——Coagulation (Alum) ——Sedimentation–Filtration (through sand bed).

Sample C - River water——Coagulation (Alum) —— Sedimentation Filtration (through sand bed) ??Chlorination.

Sample D - River water——Coagulation (Alum)——Sedimentation ——Filtration (through sand bed) ——Chlorination ——Adsorption (through activated——charcoal)

Sample E – River water —— Coagulation (Alum) —— Sedimentation —— Filtration (through sand bed) —— Adsorption (through ion exchange resin) —— Chlorination

## RESULTS AND DISCUSSION

Table 1 shows the results of chemical and microbiological analyses of the three samples of raw water in comparison with the World Health Organization (WHO) standard. Chemically, the pH of Adiyan and Matogun streams are too low while the turbidity and iron content of Legun river are too high. Microbiologically, the three samples are: free from coliform - a health hazard constituting organism; have a number of total plate count in an amount that is not too high and can be eliminated by boiling or filtration; are positive for mould but not too high.

Table 2 shows the values obtained for different level of alum concentrations. The result shows that an increase in the levels of alum, causes a corresponding decrease in

Table 1. **Chemical Analyses of Raw Water Samples**

| Constituents | Adiyan | Matogun | Legun | W.H.O Standard |
|---|---|---|---|---|
| Appearance | Clear | Clear | Cloudy | Clear |
| pH | 5.45 | 5.57 | 7.20 | 6.5–8.5 |
| Turbidity (NTU) | 1.0 | 0.5 | 4.1 | < 5 |
| Conductivity (usan) | 26 | 25 | 76 | 2500 |
| Temp. (°C) | 31 | 31 | 31 | |
| Total Solids (ppm) | 56 | 60 | 194 | 500 |
| Total Dissolved Solids (ppm) | 40 | 40 | 126 | 500 |
| Suspended | 16 | 20 | 68 | Variable |

| | | | | |
|---|---|---|---|---|
| Matter (ppm) | | | | |
| Total Hardness (ppm) | 14 | 10 | 39 | 100-500 |
| Calcium Hardness(ppm) | 3.65 | 4.26 | 29.26 | 75 |
| Magnesium Hardness(ppm) | 10.35 | 5.74 | 9.94 | 50 |
| Total Alkalinity (ppm) | 19 | 210 | 58 | Variable |
| Sodium (ppm) | 2.54 | 2.69 | 4.61 | — |
| Potassium (ppm) | 0.16 | 0.13 | 4.61 | |
| Iron (ppm) | 0.325 | 0.20 | 1.85 | 0.3 |
| Chloride (ppm) | 10.65 | 10.65 | 10.65 | < 5 |
| Nitrite (ppm) | 0.002 | N.D | 0.004 | 3.0 |
| Total Plate Count (ml) | 8 X $10^3$ | 2.6 X $10^3$ | 4.1 X $10^3$ | 1 X $10^2$ |
| Yeast / Mould Count (ml) | +vc | +vc | +vc | 1 X $10^2$ |
| Coliform Nil Count (ml) | Nil | Nil | — | |

Table 2. **Different Levels of Alum Concentrations.**

| Alum Concentration (ppm) | pH | Turbidity (NTU) | Conductivity (usan) |
|---|---|---|---|
| 0 | 7.20 | 62 | 76 |
| 10 | 6.15 | 66 | 86 |
| 20 | 6.16 | 66 | 66 |
| 30 | 6.14 | 66 | 66 |
| 40 | 6.10 | 66 | 66 |
| 50 | 5.57 | 66 | 66 |
| 60 | 6.15 | 66 | 66 |

the pH of the water. However, the level of depression(1 pH unit) was not appreciable. The turbidity also decreased up to 60ppm before rising. The use of alum is to decrease turbidity, so a concentration of 60ppm was found to be adequate. Even though there was increasse conductivity at 60ppm, it was not an apprecible one.

Table 3 shows the variation of pH value with turbidity. The optimum pH value at which turbidity was minimal was found to be 7.9. This pH value was used in all subsequent experiments where coagulation with alum was found necessary.

Table 3. **The Variation of pH Value with Turbidity**

| pH | Turbidity (NTU) | Conductivity (usan) |
|---|---|---|
| 3.82 | 36.0 | 138 |
| 4.79 | 46.0 | 114 |
| 6.03 | 39.0 | 90 |
| 7.02 | 39.0 | 75 |
| 7.90 | 14.0 | 78 |
| 7.20 | 39.0 | 78 |

Table 4 shows the results of analyses of samples of river water treated at five different levels. The results of chemical analyses of the treated water show tremendous improvement in the quality of the water after treatment.

Table 4. **Chemical Analyses of Treated Water Samples**

| Constituents | A | B | C | D | E |
|---|---|---|---|---|---|
| Appearance | Clear | Clear | Clear | Clear | Clear |
| pH | 3.89 | 6.91 | 7.10 | — | 4.47 |
| Turbidity | 3 | 4 | 0.7 | 1.5 | 1.5 |
| Conductivity | 40 | 48 | 105 | 350 | 06 |
| Iron (ppm) | 0.06 | 0.02 | 0.02 | — | — |
| Total solid (ppm) | 8 | 8 | 10 | 38.4 | 0.5 |
| Yeast/Mould Count (ml) | 4 X 10⁻¹ | 5 X 10⁻¹ | Nil | Nil | Nil |
| Coliform Count (ml) | Nil | Nil | Nil | Nil | Nil |
| Total Plate Count (ml) | 3.4 | Nil | Nil | Nil | Nil |

They were microbiological acceptable because they did not carry any form of microbial count. The result of the chemical analyses also showed an improvement in the water quality from sample A – E. Except for the pH, the river water could be effectively treated as in E.

## CONCLUSION

It is believed that a successful commercialisation of this project will be of immense assistance to both public and private sector – establishments anxious to provide potable water to Nigerians.

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