DESIGN OF A MINI WATER TREATMENT PLANT FOR IZOM TOWN IN NIGER STATE

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PGD/2000/2001/123

SCHOOL OF POST GRADUATE STUDIES
FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA
POSTGRADUATE DIPLOMA (PGD) IN AGRICULTURAL ENGINEERING
(SOIL AND WATER ENGINEERING OPTION)

APRIL, 2005

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A PROJECT REPORT SUBMITTED

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APPROVAL PAGE

This project titled "Design of mini water treatment plant for Izom town in Niger State" was carried out by Ahmed Adamu Gambo a postgraduate student in the department of Agricultural Engineering with Registration Number PGD/AGRIC ENG/2000/2001/123 and have been certify by the undersigned to have met the requirements for the award of postgraduate diploma (PGD) in Soil and Water Engineering.

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DEDICATION

This project is dedicated to my mother Hajiya Hussaina Adamu

ACKNOWLEDGEMENT

I am grateful to the Almighty Allah for is infinite mercies on me.

My sincere appreciation goes to my project supervisor Dr. B. A. Alabadan who relentlessly guided me to writing this project, and the HOD Agricultural Engineering Dr. D. Adgidzi and all the lecturers in the department.

I am also indebted to Engineer Mohammed Bashir for his assistance, similarly the contributions of Ibrahim Manta, Abdullahi Top Zulu, Bala Mohammed of Niger State Water Board laboratory and the staff of Usuma Dam laboratory are highly appreciated especially Madam Lola.

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ABSTRACT

The Izom community is a rural set up in Niger State of Nigeria with abundant surface water resources through the Gurara river at Izom. The minimum flow rate of the river is $11548.8m^3$/day, where as the estimated water requirement was found to be $500m^3$/day.

The quality of the water did not meet the WHO requirement for portability. A mini water treatment system was designed to be able to provide water for the community upto the year 2020AD. The treatment system was recommended to the community for construction in view of the support they have shown to a scheme like that.

CHAPTER ONE

1.0 INTRODUCTION

1.1 Introductory notes

The need for the provision of portable drinking water to Izom community with a population of about three thousand people can not be over-emphasized.

This small town called Izom is blessed with abundant surface water resources from Gurara river, and there is need to provide a purified water to its inhabitant, as this will go a long way in reducing the prevalence of water borne diseases in the community.

1.2 Location of Project Area

Izom is a small Town located in Gurara local government area of Niger state, along Minna-Suleja road toward Suleja end of the road. Izom is also situated in-between latitudes 11^{o}00'N and longitudes 8^{o} 30'E .The topographic map of the area is shown in fig 1.

1.3 Climate And Vegetation

The climate of this area is characterized by dry northern winters and wet northern summer, and the vegetation is basically savannah (southern guinea savannah grassland) inter spread with tropical forest remnants.

1.4 Hydrology

Gurara river has a catchment area of six thousand two hundred at izom.

The river is oriented NE-SW with its lead waters originating from the west of the Jos Plateau and the basin also lies in the intermediate zone between semi arid in the north, and subhumid in the south. The terrain is undulating and dissected conforming to the

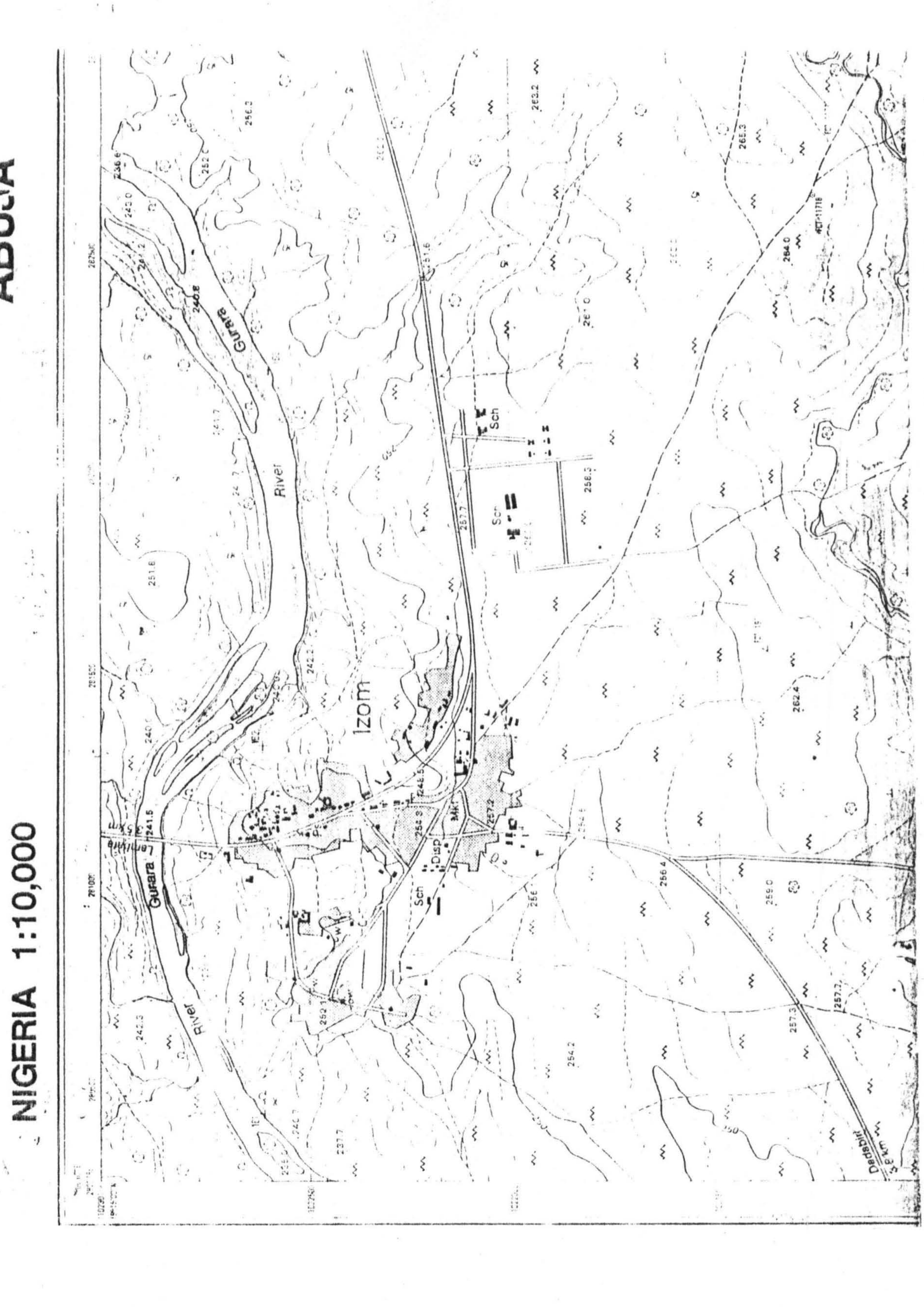


Fig 1: Topographic map of Izom ccommunity

dominant structure of underlying rocks undifferentiated basement complex, (Jimoh, et al. 1992)

1.5 Aims and Objectives

The aim of this project is to design a water treatment plant for the town, in order

to supply the community with water that is safe and appealing.

The objectives are:-

a) Determine water requirement of the community.
b) Determine the raw water quality.
c) Design of treatment plant that will correct the negative qualities if any.
d) Design a simple storage/reservoir tank.

1.6 Justification

Apart from the local population, the community host one of the most prominent

Science College in the country, with students and teachers drawn from different parts of the country and different parts of the world respectively. Where future doctors, pharmacist, scientist, engineers are being trained, so the provision of safe water in this community will ensure good sanitation, enhance socio-economic activities in the area.

1.7 Scope Of The Study

The scope of this work is limited to Determining the water requirement of the Izom community, and Analyzing the raw water Quality and Design of simple water treatment plant.

CHAPTER 2

2.0 LITERATURE REVIEW

2.1 Water Quality

Water is purified or treated to get rid of harmful substances or reduce them to the minimum permissible limits to make them safe and fit for human consumption or suitable for intended general domestic uses. (Abuja water news, 2003) water quality is affected by the presence of or absence of organic and inorganic matter.

Water is represented by the expression of H_20. This means that water consist of two types of elements that is substances that cannot be divided into simpler ones. These elements are hydrogen (with symbol H) and oxygen (with symbol O). Two atoms of hydrogen combined chemically with one atom of oxygen to form one molecule of water.

Laboratory control test provide the necessary information to monitor the treatment processes and ensure a safe and good tasting drinking water for all who use it. By relating laboratory results to treatment operations, operators can first select the most effective operational procedures, then determine the efficiency of the treatment processes, and identify the potential problems before the affect the finished water Quality. (NWRI, 1997).

Some of the substances that are present in water and which affects water quality are:-

Materials in Suspension:- Such as sand, sludge, rocks, debris, organic materials and plants.

Colloidal Materials:- They include colloidal organic material, mineral oils, petrol, tars and clays.

Soluble Organic Materials:- Vegetable wastes and nitrogenous materials and products of organic synthesis are some examples.

Mineral Salt:- Some of the mineral salts that could be found in water include, bicarbonates, sulphates, nitrates, chlorides, calcium, sodium, magnesium, etc.

Gas:- Gases like oxygen and nitrogen, carbon gas and ammonium could be found in water.

Living Organisms:- Plant and animals like plankton, algae, fungi, worms, larvae, bacteria and virus are some examples (NWRI 1997).

2.2 Water Treatment

For a very longtime people have dreamed of imitating nature to purity unclear or

contaminated water. At first it was considered sufficient to clarify water by passing it through sand masses or porous surfaces; then people became more demanding as scientific progress discovered new impurities, and every possible procedure for improvement was resort to: physical, chemical, mechanical and biological, separately or jointly (Sterling Publications Ltd. London W2 1XR 1996).

The basic objective of water treatment is the production of water which is safe for human consumption.

a) water quality criteria that is of first priority is Design criteria Treatment/Distribution.

b) Production of water appealing to consumers is the second priority. Design criteria--- insure production of uniform water qualities.

c) production cost should be reasonable, and treatment processes should be based on locally available materials, operating manpower and maintenance as much as possible.

Some of the water quality parameters that are of:-

First priority in water treatment are, E.coli, coliforms, turbidity, electrical conductivity, fluoride, iron, nitrate and km no_4.

Second priority in water treatment are; PH colour, taste, Alkanity (CO^2_3 or HCO_3) and hardness.

2.3 Rural Water Treatment

In most rural areas especially in the developing and underdeveloped nations, water is treated by boiling it and using net to filter it and thereafter allow it to settle. But in some developing countries and developed world treatd water is available in rural areas.

2.4 Treatment Procedure

2.4.1 Sedimentation

This is a physical treatment process in which particles with a higher mass density than the surrounding liquid will move downwards under the influence of gravity.

In water treatment, sedimentation is a primary treatment process e.g when using Rapid Sand Filters (RSF) or Slow Sand Filters (SSF) for filtration, RSF requires water with turbidity of 10-20 parts per million of slow sand (SS), while SSF can filter water with 2-5ppm of SS directly without pretreatment. (Mbuatte, 1981).

Sedimentation requires a square, round or rectangular tank or basin, the tank reduces velocity and turbulence, thereby removing particles, and the tank has four zones.

i) **Inlet or Influent Zone**:- This reduces the velocity of the incoming water and distribute the flow evenly across the base.

ii) **The Settlement Zone**:- This provides a quiet calm zone for the suspended materials to settle.

iii) **The Effluent Zone**:- It provides smooth transition from the settlement zone to the effluent flow area. It is important that current do not stir any settled solid and carry them into the effluent zone.

iv) **Sludge Zone**:- Where solids are separated from the rest of the particles. As particles settle to the bottom of other tank, a sludge zone develop, if the layer gets too thick the solid can be resuspended or tastes or odour can occur from the decomposing organic matter. Sludge must be periodically removed manually or mechanically. (N.W.R.I. 2003).

When a discrete particle with a density ρs is greater than the density of a fluid (water Pw), it is released in quincent conditions, it will accelerate downwards until the frictional drag (Fd) of the fluid equals the value of the impelling force (Fi) after which the vertical velocity of the particle with respect to surrounding fluid will remain constant as S

So= over flow rate or surface load of the sedimentation tank:

$$S_o = \frac{QH}{LBH} = \frac{Q}{BL} = \frac{Q}{A}$$

So depends on the discharge and surface area of the plain sedimentation tank, and particles with settling velocity greater than so will all be removed: (I-Po) % . other particles traveling at less than so but lower than so will be removed partially.

2.4.2 Sizing of tank :- The following design criteria are followed:

i) $A = \frac{Q}{S_O}$

So should be chosen according to the effluent water quality requirement which is established by laboratory test on raw water.

ii) In order to ensure minimal or no reduction in basin settling efficiency and to simulate quiescent conditions, rectangular horizontal flow plain sedimentation tanks require that:

(a)Length: width be controlled such that L : B = (6-10) this ensure existence of plug flow conditions. In plug flow, there is no mixing of particles during flow.

(b) To take care of the basin instability and short circulating, the Rey nold's number and froude number should be kept such that

$$R_e = \frac{V_O R}{\nu} \leq 2000 \qquad \text{and} \qquad F_r = \frac{V_O^{\,2}}{R_e} \geq 10^{-5}(\mathit{flowstability})$$

Where :

R = Hydraulic Radius $= \frac{A}{P}$

P = Wetted Perimeter

Vo = Horizontal flow velocity in m/s

Note: that in practice compliance with Fr is more important than Re.

iii) **Bottom scour velocity**

Settled solids should not be scoured off the basin: scour bedins if thr scour velocity Vs

$$V_S = \sqrt{\frac{8\beta(\rho_S - \rho_w)gd}{\rho_{w\varphi\lambda}}} \leq V_O$$

With β 0.05 (grain friction factor)

λ =0.03 (hydraulic friction factor0 occur if Vo < Vs.

iv) In practice the shape of the settling zone is a compromise between one hand hydrodynamic requirements and on the other hand, the economic considerations.

As rule of thumb, formula H= ½.< 0.8 gives a sufficient and acceptable depth for tanks provided with continuous sludge removal mechanism. For manual cleaning or otherwise, allow say a storage depth of at least 1.0m. In addition, by considering the construction site constraints like GWT and excavation, the total depth of such tanks 'H' usually lies in range of 2 – 6 metres.

Some of the common values of over flow rates, so for sedimentation Tanks are given below:

Table1 : Specific gravity of some soil material and their So

	SPECIFIC GRAVITY	So (m/h)	REMARKS
Silt, Clay, Sand	2.65	0.2 – 0.5	Plain sedimentation
Alum/iron flocculated salt	1.002	0.6 – 2.0	Flocculated sedimenta
Primary (raw) waste organics	1.001	1. 0–2. 0	--- do -----

2.4.3 Detention Time :

Td = 2-4-6 hours for plain sedimentation.

The detention time should be kept on the higher side in case of :

Time light particles

Requirements with respect to high removal efficiency. (Mbwatte, 1981)

2.4.4 Aeration

It is used to introduce oxygen into the water or to remove such gases as carbon dioxide, sulphur dioxide, hydrogen sulphide. Aeration can also used to removed iron and manganese, by converting soluble iron or manganese into in soluble iron or manganese by introducing oxygen. The commonest method is the spray area for which produces very fine droplets of water in a spray. A second method is the "force drought tower", water trickles down through a parked tower while air is blown upwards (N.W.R.I 2003)

The exchange between a liquid and a gas at a gas-liquid interface results into absorption of the gas if the liquid is not saturated. If the liquid is over saturated the same results into "gas desorption" or sometimes gas stripping.

Release of gases like:-

(i) Removal of CO_2 to adjust or approach the carbonate equilibrium w.r.t calcium

(aggressivity control)

(ii) Removal of H_2S to eliminate taste an odours and to decrease corrosion of metal and disintegration of concrete.

(iii) Removal of methane to prevent fire disaster and/ or explosions

(iv) Removal of volatile oils and similar odour and taste producing substances.

(v) Removal of ammonia from sewage as a means of reducing eutrophic conditions of receiving water especially lake

Some of the factor that affect aeration however include:-

(i) Differences between saturation and actual concentration of gases in water to be aerated, thus (Cs-C) respectively and sometimes called "derive force".

(ii) Inter facial area permit volume of water, a=A/V.

(iii) The transfer coefficient, K2 which also depends on temperature, viscosity and density.

2.4.3 Coagulation and flocculation;

Is the stage where in water treatment chemicals are added to the water, and the purpose of this is to remove, colour, turbidity, hardness, taste, odour and excessive dissolved chemical.(N.W.R. I 2003)

The idea is to stick particles together so as to form a bigger particles called floccs which are more readily settleable than individual particles. During Coagulation chemicals like Fe and Al- salts are added to water in order to transform the impurities (colloids, suspended matter, phosphate and heavy metals) after reaction with the hydrolyzing salts into large floccus which can be removed efficiently by sedimentation and filtration.

Flocculation essentially refers to the process agglomeration of the destabilized particles to settleable or filterable floccs, this process take place in two phases:-

(i) Colloidal range (inm-nm0 Browniani motion is responsible for agglomeration to Mm size.

(ii) With particles having d>im ----> slow mixing aids the agglomeration. (

Clarification follows four stages:

i) Chemical dozing which is the addition of the coagulant chemical rapid and through mixing is vital to ensure that all the water comes into contact with coagulant chemical.

ii) Precipitation of micro aggregate: - This stage happens as soon as the coagulant chemical is dosed. Flocs form as minutes particles; because of their size they have high surface area.

iii) Adsorption of colour and impurity:- This impurity is adsorbed into the surface of the micro-aggregate due to surface electric charges.

iv) Build up of large floc particles:- The adsorption of impurity onto the surface increase the size, also particles collide and stick to each other. Therefore, the mass increases, floc becomes settleable. It occur best in gentle turbulence. (N.W.R.I. 2003)

2.4.5 Filtration:

A rapid gravity filter follows some form of sedimentation tank to remove any last traces of impurity from water. (N.W.R.I. 2003)

Filtration is the purification process whereby water to be treated is passed through a porous medium. During this passage, water quality improves by :-

i) The removal of suspended and dissolved solid contents.

ii) Removal of floating and colloidal matter.

iii) Reduction of bacteria and other pathogenic micro-organism

iv) Changes in other chemical constituent,

The overall removal of impurities which is associated with the process of filtration is mostly brought about by the following:-

i) Mechanical straining

ii) Sedimentation.

iii) Adsorption

iv) Chemical activities.

v) Biological activities (Mbwatte, 1981)

The beginning of the century (1901) saw the first rapid gravity being installed at york. This was to provide 13,260m day (3 mgd).

This filter was built on wood, but in (1901) the first reinforced concrete filter was built.

This was very similar to the filter constructed today. (N.W.R.I.2003)

Slow filtration was thus the first of these water treatment technologies. It saw the light of the day in England, Belgium, Germany and the Netherlands during the last years of the nineteenth century. It was introduced to France in 1896.

It is nevertheless remarkable that this technology has remained with only a few improvements, practically the only one for half a century- if one does regards the introduction of chlorination the second major event in history of water treatment and a technological legacy from the First World War.

Indeed it was only during the second half of the twentieth century that rapid filtration was introduced under the dual pressures of demographic development and eutrophic pollution that were just beginning to make themselves felt. Capacity to produce slow filtration at that time depended largely on increases in river levels and the presence of algae. This technology also needed too much space.

It was soon discovered that rapid filtration technology, however attractive did not disinfect water safely as slow filtration and in many countries organization was used to complement it. (World water, 1996).

Filtration could be by gravity or pressure:

i) Gravity filtration:- water passes through the media by gravity, ie influent

and effluent are both at atmospheric pressure.

ii) Pressure filtration:- it is usually done in closed vessel (usually of steel), water enters and leaves under pressure. Advantages are that water can enter a pressure system without necessity of intermediate pumping eg Industry, Swimming pool etc.

Filtration can also be downwards (down flow) or upwards (up flow) (Mbwatte, 1981)

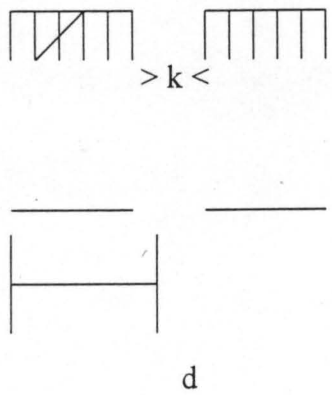
i) Mechanical straining

This is the process involving the removal of particles of suspended matter that are too large to pass through the infectices. As such, it takes place at the top surface of the filter bed surface and is generally independent of the filtration rate.

This process is not able to retain colloids which are in the size of 0.01- 10mm or bacteria (0.1-15mm).

If floc formation occurs in the sand bed, the flocs will be retained with this process.

mechanisms are gravity inertia, diffusion, hydrodynamic force and turbulence. Electrostatic attraction and adsorption. Physical attraction (vander weals forces) :



Two particles at a distance d c/c apart attract each other with a force k

The force has deep influence into the body of the passing liquid. For instance, very charged as well as colloid matter of organic origin repulsion occurs initially. Thus the filter media needs a ripening period during which a positively charged surface is built up.

(iv) **Chemical Activities**

This is the process by which dissolved impurities are either broken down into simpler, less harmful substances or converted into insoluble compounds which can be removed by either of the previous three process thereafter.

-- Oxidation of organic matter to Co_2 All these processes consume O_2 and take

-- Oxidation of Ammonia to Nitrate place on surface of the filter grains.

-- Fe^{++} to Fe^{3+}

-- Mn^{2+} to Mno_2

Therefore, adsorption processes are pre-requisites for this removal mechanism.

(v) **Biological Activities**

These are most predominant in slow and filters (ssf) which form the living quarters for organism at the top of the filter bed usually called Schmutzdecke. The biochemical activities of micro-organisms living here result into high improvements in bacterio-logical quality of water being filtered. Due to the high filtered porosity. R.S.F bring about very negligible improvements of bacteriological quality of water filtered.

These processes break down organic matter to such innocent compounds as water, Co_2, No_3, Po_4 (by mineralization) which are discharged with the filtrate.

Note that: -

V_f = Filtration rate = Q/A m/h

Comparison of SSF Vs RSF

Where:

Q = discharge (m^3 / hr)

A = plan area of filter bed in (m^2)

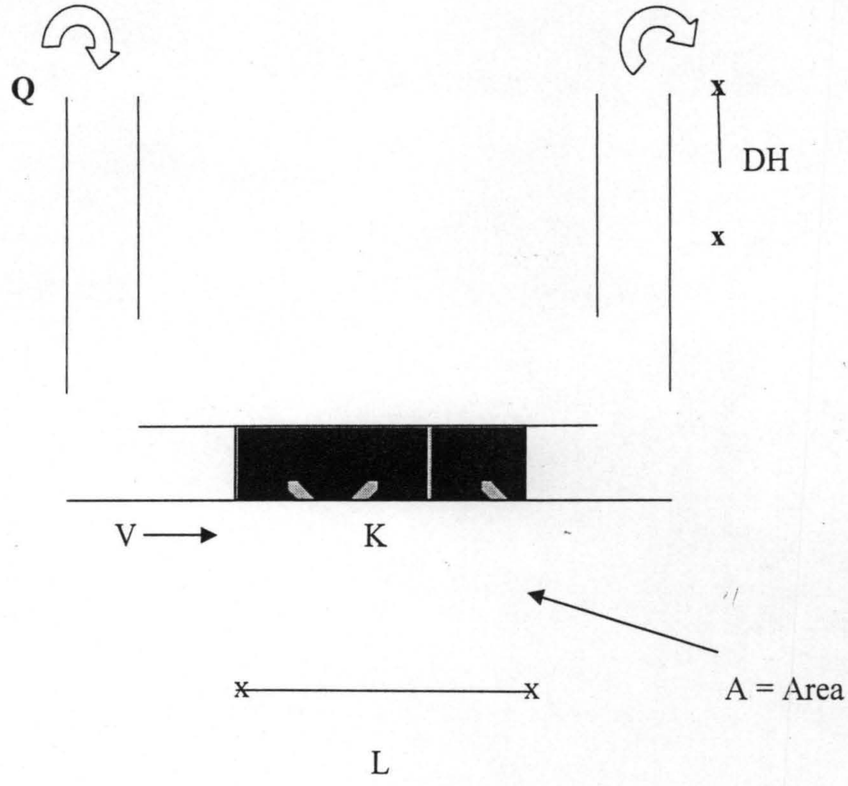
V_f= rate of fall of w.l when the influence is closed.

Table2: Comparison of SSF and RSF filter

NO	PARAMETER	SSF	RSF
1	Filter loading or filtration rate Vf	0.1 – 0.4 (m/h)	5 – 15 (m/h)
2	Detention time Te	Several hours	A few minutes
3	Filter Materials	D10 = 1.15 - .35mm Uc = d10/d10 $\leq$ 2 – 3 only relatively fine media used. Usually sand	D10: 0.5 – 2mm Uc $\leq$ 1.2 – 1.3 Sand, anthracite coal magnetile, plastics, coconut fibres.
4	Filter run	3 – 12 months	1 – 3 days
5	Filter depth	0.6 – 1.5m	0.5 – 2.0m
6	Major filtration mechanisms	All five mechanisms	Adsorption, sedimentation and chemical actions
7	Method of clearing filter bed	Skimming off 2 – 3m of sand	Back washing (water/air) in reverse direction to normal flow
8	Equipment and accessories	Few simple	Many and sophisticated.
9	Land requirements	Large	Small (20% of SSF)
10	Construction costs (excluding land acquisition)	High	Low
11	Operational cost	Very low	Very high

(vi) **Hydraulics of SSF**

the filtration is so small that the flow is assumed to be lamia and hence Darcy's law can be used: -



From above Dercy's conclude that

$$V = Q/A = K . DH/L$$

Where, K = permeability of filter material (m/sec)

DH/L = Hydraulic gradient. (mm = -)

$DH_o = V.L/K$

With continued operation of filter:

K- decreases due to impurities which clogg the filter.

DH – Increases

V = remains constant (until end of filter run)

DS = specific diameter and is defined as

$$Ds = d10 \underbrace{(1 + 2 \log_{10} Uc)}_{4}$$

where $Uc = \frac{d\,60}{d10}$ coefficient of uniformity usually $\leq 2 - 3$

the value of permeability of the SSF bed can best be determined by laboratory experiments with a representative sample. However in practice, often the following empirical approximate formula can be used.

$$K = 180\,(0.72 + 0.028t)\,P^3\ .\ 4^2\ .\ 4^2.\ d10^2\ (m/h)$$

Where, t = Temperature in ^{o}C

P = Porosity of the sand bed

P = Shape factor

P = The term $(1 + 2\log_{10} Uc)$

CHAPTER 3

3.0 MATERIAL AND METHOD

A reconnaissance survey of the area was carried out; this was followed by with distribution of questionnaires to the inhabitants of the area

3.1 Reconnaissance Survey

A preliminary survey of available physiographic, geographic and hydrologic data of the town was carried out. This involve the compilation of the area population data from National Population Commission of Abuja, compilation of the hydrologic data of the Gurara river was compiled from Niger State Water Board headquarters in Minna; the topographic map was collected from lands and survey department of Ministry of Federal Capital Abuja. The area was also examined for possible site of the intake of the treatment plant and distribution and storage system.

3.2 Questionnaire

Questionnaires were distributed to the inhabitants of the town. The questionnaire was designed to address the people usage of water, source of water use, water requirement per household/person and the problems encountered in the present source of water. This is with a view to finding out the desirability or otherwise of a mini water treatment plant for the town.

3.3 Water Requirement Computation

3.3.1 Population Water Requirement.

The 1991 National Census by the National Population Commission gave the figure for the town as shown in the table below.

Table3: population of male and female in Izom community, 1991 Census.

Population	Male	Female	Total
1zom Township	411	317	728
1zom School	1230	55	1285
			2013

(National Population Commission (NPC), 1991 Census)

The population was then projected to the year 2020, to account for increase in population over these years.

This was calculated using the formula

$$Pj = Po\,(1 + r)^{n}$$

Where :

Pj = Projector Population

Po = Initial Population

r = rate of Increase of population (%)

n = number of years projected.

Po = 2013

The national population growth rate is estimated at 5% for rural areas in 1991.

r = 0.05

n = 2020 – 1999 = 21 years

$Pj = 2013\ [(1 + 0.05)^{21}]$

$= 2013\ (1.05)^{21}$

$= 5608$

3.3.2 Per Capita Demand

The Per Capita demand for rural community as recommended by UNICEF is 50l/ c/d, but this is a minimum. However during the examination of the inhabitant through the questionnaire, it was discovered that the 1zom Science college student use about 60l/c/d. this was therefore used as the basis for the demand of the entire town.

Considering the population of 5609 by 2020AD, the population water demand

$= 60 \times 5609$ l/d

$= 336540$ l/d

$= 336540/1000$

$= \mathbf{336.540m^3/d}$

3.3.3 Fire Demand

The fire demand for the town was computed using

$= 3860\sqrt{P}.\ (1 - 0.01\sqrt{P})$

$Q_f = 3860 \times 74.89\ (1 - 0.01 \times 74.89)$

$= 3860 \times 74.89 \times 0.2511$

$= 72586.83$ l/d

$= 72586.83/1000$

$= \mathbf{72.587\ m^3/d}$

3.3.4 Sanitation Demand

The water required can be computed using;

$Q_S = Q_W =$ amount for waste

$Q_S = Q_{P/10}$

$= 33.654m$

$= \mathbf{33.654m^3/d,}$

Total water requirement

$Q_P + Q_f + Q_S$

$= (336.540 + 72.587 + 33.654)\ m^3/d$

$= 442.781m^3/d$

Allow for 10% contingency = $44.278m^3/d$

Total water requirement

$= 442.781 + 44.278$

$= 487.059m^3/d$

Assume water demand to be $\mathbf{500m^3/d}$

3.3.5 Estimation of Flow Rate at Gurara

The flow rate of gurara river at Izom guage station for two seasons 1989-1990,were critically examine to identify the stress (drought) periods and to find out how long it will last. The daily flow readings of the station were analysed, the daily, monthly minimum, maximum and mean values were also determined.

The table below shows the minimum, maximum and mean flows over the river during this period.

Table4 :Daily minimum, maximum and mean flows in gurara river 1989—1990

Year	Month	Min m^3/s	Max m^3/s	Sum m^3/s	Mean m^3/s	Meanm^3/d
1989	Jan	0.43	0.75	15.72	0.524	4527.6
	Feb	0	0.95	12.59	0.419667	36259.2
	Mar	0.15	0.42	8.26	0.275333	23788.8
	April	0	0.81	6.39	0.213	18403.2
	May	0.42	1.75	25.77	0.859	74217.6
	June	0	1.8	39.85	1.328333	114768
	July	0.89	2.75	36.65	1.2211667	105552
	Aug	1.04	4.44	82.01	2.733667	236188.8
	Sept	0	5.24	90.38	3.012667	260294.4
	Oct	1.01	2.77	52.07	1.735667	149961.6
	Nov	0	0.99	22.55	0.751667	64944
	Dec	0.43	0.59	15.99	0.533	46051.2
1990	Jan	0.24	0.42	10.15	0.338	29232
	Feb	0	0.24	5.07	0.169	14601.6
	Mar	0.02	0.54	4.01	0.134	11548.8
	April	0	0.97	8.86	0.295	25516.8
	May	0.75	2.3	40.54	1.351	116755.2
	June	0	2.42	44.13	1.471	127094.4
	July	1.12	3.35	57.54	1.918	165715.2

	Aug	1.29	3.94	81.21	2.707	233884.8
	Sept	0	3.54	45.4	1.513	130752
	Oct	0	3.88	86.18	2.872	248198.4
	Nov	0	2.91	64.83	2.161	186710.4
	Dec	1.53	1.74	49.87	1.663	1403625.6
					MIN	11548.8
					MAX	260294.4
					MEAN	108722

3.5 Analysis of water quality

3.5.1 Sampling points

The sampling points were used along the Gurara river at about a hundred (100) meters apart, at the up stream, the Izom bridge and the down stream of the river. Those samples were taken to the laboratory with the aid of a refrigerated container in cover bottles. The samples were analysed for

i) Physical parameters like:-

a) Odour

b) Colour

c) Turbidity

d) P^H

ii) Chemical parameters like:-

a) Total solids

b) Total dissolved solids

c) Total Alkalinity

d) Acidity

e) Chlorides

f) Hardness

g) Iron

h) Nitrate.

While the

iii) Bacteriological Parameter examined are:-

a) Total Plate count

b) Feacal Coliform .

The methods used in the examination are explain below.

3.5.2 Detection of odour

Procedure :

i) Pipette known volumes of the sample into each of several 500ml conical flasks.

ii) Dilute each to 200ml with odour free water. Shake and stopper.

iii) Heat these delusions and the reference odour-free water to 40 -60^0C

iv) Shake the flask (reference first) open and sniff the vapour.

v) Repeat sniffing of vapour on the samples starting from the lowest dilution and record observation.

Result :

T.O.N = Dilusion factor that makes the odour just detectable if the total volume is not 200m1, T.O.N is computed as shown below:

$$T.O.N = \frac{A + B}{A}$$

Where A = m1 of sample

B = m1 of odour free water.

3.5.3 Determination of colour

Procedure

i) Fill tube to the mark with distilled water and place in the left sample position1 on the comparator.

ii) Fill the other tube also to the mark and place in the right sample position.

iii) Place the colour disc and rotate to match the colour.

iv) Record the number on the disc.

3.5.4 Determination of turbidity :

A single parameter turbidimeter was used to determine the turbidity of water. The turbidity meter directly displays the turbidity of the water in the johnltasken turbidity unit (J.T.U)

3.5.5 Determination of PH.

Method : Using electrometrically glass electrodes

Reagents: Buffer solution of PH4 and 9

Procedure :

i) warm the PH meter for 15-20 minutes

ii) remove the electrode from inside distilled water rinse with fresh distilled water and dry.

iii) Standardize the meter using buffer solution at temperature specified (20^0 or 25^0C).

iv) Switch off the PH knob. Remove the electrode from the second buffer rinse thoroughly and wipe with soft tissue.

v) Insert it into the sample, switch on the PH knob and take the reading on the scale.

vi) Rinse the electrode again an d store immerse in distilled water.

3.5.6 Determination of total solids :-

Procedure:

i) Clean a 100ml porcelain evaporating dish and place in an oven for 1 hour at 105°C .

ii) Remove and place it in a desiccators to cool and then weigh.

iii) Place the weighed dish on a boiling water bath.

iv) Thoroughly mix the water sample and transfer qualitatively 50ml or 100ml of it into the dish and rinse the measuring flask of pipette with small portions of distilled water. Ensure that all suspended matter is transferred to the dish.

v) After the sample is evaporated, dry the dish and residue in the 105°C oven for two hours.

vi) Return into the oven for 10 minutes, again remove, cool in the desiccator and reweigh.

vii) Repeat until a weight is constant.

CALCULATION:

$$\frac{\text{Difference nwt. (gm) x}10^6}{\text{Ml of sample.}} = \text{ppm total solids.}$$

3.5.7 Determination of total dissolved solids :

Filter a portion of the water sample. Follow the procedure for total solids determination using 100ml of 50 ml of the above filtrate.

Calculation:

$$\frac{\text{Difference nwt. (gm) x } 10^6}{\text{ml of sample.}} = \text{ppm dissolved solids.}$$

3.5.8 Determination of total Alkalinity .

The sample is filtrated against standardized acid using: methyl orange indicator and phenolphthalein indicator.

Procedure:

i) Pipette 10ml of the water sample into a conical flask and 3 drop of phenolphthalein indicator.

ii) If the sample becomes pink, filtrate with 0.002N sulphuric acid until the pink colour just disappears. Record the litre.

iii) Add 3 drops of methyl orange indicator to each flask

iv) If the water sample becomes yellow, add 0.02N sulphuric acide until the first difference in colour is noted, when compared with the distilled water. The end point is orange. (methyl orange is yellow in alkaline solution, orange in neural and red in acid)

v) Record the litre.

CALCULATION:-

$$\text{Total Alkalinity ppmcaco}_3 = \frac{\text{Titre } 0.02 \times 50000}{100}$$

$$= \text{Titre} \times 10.$$

3.5.8 Determination of Total Acidity

The sample is titrated against standard sodium hydroxide solution, using phenolphthalein indicator for total acidity and methyl orange indicator for mineral acidity.

Procedure:

i) Prepare 1.0N solution of sodium hydroxide using standard concentration in

ampule when available. Then prepare 0.02N of sodium hydroxide solution by diluting a calculate volume of the stock solution with distilled water which has been freshly boiled for as least 10 minutes to expel carbon dioxide.

ii) Pipette 100m1 of water sample into a conical flask and add 3 drops of phenolphthalein indicator.

iii) Titrate with 0.02N sodium hydroxide from a burette until the first permanent pink colour appears and record the number of sodium hydroxide used (titre)

CALCULATION

Total Acidity as $CaCo_3$ = (Titrex10) ppm.

3.5.9 Determination of Hardness :

Procedure

Pipette 100ml of water sample each of 250ml conical flask.

ii)Add 1ml of buffer solution. Swirl and add 3 drops of indicator.

iii)Titrate against 0.02N EDTA solution until change of odour occurs.

iv) Standardize the EDTA solution against the standard calcium solution using 10ml portions to check the EDTA titre. Dilute the 10ml to 50ml in water.

CALCULATION

Total hardness ($CaCo_3$) equivalent to 1.00ml of EDTA titrant.

3.5.10 Determination of chlorides : Argentometric method

Procedure

i) Transfer 100ml (or smaller volume diluted to 100ml) in to a 250ml conical flask. It is highly coloured or turbid add 3ml Al $(OH)_3$ suspension mix and allow to settle. Filter, wash and combine filtrate and washing if sulphide, sulphate, or thiosulphate is present at ml of H_2O_2 and stir for 1 minute.

ii) Titrate triplicate samples in the PH7-10 dinecthy with standard $AgNO_3$ solution using 1ml k_2Cro_4 indicator, to a pinkish yellow end point (if necessary adjust p_4 with H_2So_4 or NaoH solution).

iii) Standardize the $AgNo_3$ titrant 0.01N Nacl solution 1ml $AgNo_3$ solution = 500 Nacl (1mi).

iv) Establish a reagent blank value using distilled water.

CALCULATION

$$\text{Mg/litre chloride} = \frac{(A - B) \times N \times 35.450}{\text{M1 of sample used}}$$

Where

A = sample litre B= Blank litre and N = 0.0141.

3.5.11 Determination of iron phenanthroline method:

Procedure

i) Mix the sample thoroughly and measure 50ml into 125ml erlenmeger flask

ii) Add 2ml conc. HCL and 1ml hydroxylamine. Add few beads and boil to ensure dissolution of all iron, continue boiling until the volume is reduced to 15 to 200ml

iii) Cool to room temperature and transfer qualitatively to a 500r 100ml volumentry flask.

iv) Add 10ml ammonium acetate buffer solution, and add 2ml phenanthroline reagent.

v) Dilute to 100ml with distilled water and allow at least 10 to 15 minute for maximum colour development.

vi) Red colour in a colorimeter or spectrometer.

vii) Prepare a calibration curve for standard solution of iron and read concentration of iron.

3.5.12 Determination of Nitrate – brucine method.

Procedure

i) Prepare nitrate standards within 0.1-1mg/litre N by diluting 1,2,4,7, and 10ml standard nitrate solution (b) above to 10ml in a series of boiling tubes.

ii) Pr-treatment of sample: if the sample contains residual chlorine add 1 drop (0.05ml) of sodium arsenite solution for each 0.1mg chlorine and mix. Add 1 extra drop to 50ml portion.

iii) Arrange all the tubes in a wire rack with adequate spacing. The sample tube should contain 10ml treated sample or a smaller quantity diluted to 10ml sa that nitrate –N is between 0.1 and 0.8mg. place the rack in a cool water bath.

iv) Add Nacl solution. Mix and add 10ml H_2So_4 solution. Mix again by swirling and allow to cool.

v) If cour or turbidity develops, read the sample blank against reagent blank at 40Ngm

vi) Replace the rack of tubes in the cool water bath. Add 0.5ml brucine - sulfanilic acid reagent swirl the tubes to mix thoroughly.

vii) Place the rack of tubes in a boiling water of minimum of 95°C for exactly 20 minutes. Remove, immerse in a cold water bath and cool to room temperature.

viii) Transfer into colourimeter tubes and read standards and samples against reagent blank at 410Nm in the spectrophotometer or in a colourimeter using the appropriate filter.

ix) Check the technique by running at least two standards with each batch of samples.

x) Prepare a standard curve from the readings after deducting black reading and correct the sample reading by deducting sample black value.

xi) Read the concentration of No_3- N directly from the standard curve.

CALCULATION

$$Mg/1\ No_3 - N = \frac{Ng\ No_3 - N}{Ml\ of\ sample}$$

$$Mg/1\ No_3 = mg/1 No_3 - N x 4.43$$

Biological test procedure

3.6 Design of sedimentation tank

Designing considerations

i) Population (P_j) = 5609

ii) Overflow rate S_o = 0.4m/hr (Plain Sedimentation of silt, clay & sand from table).

iii) Coldest temperature T^oc [27^oC] (from meteorological readings).

iv) $\nu = 0.9 X 10^{-6} (m^2/sec)$

v) $\rho_s = 2500Kg/m^3$ [Assumed for raw water]

$Q = 500m^3/d = 5.79 X 10^{-3} m^3/s$

$$= \frac{500m^3/d}{60x60x24}$$

$= 5.787 X 10^{-3} m^3/s$

$$S_o = 0.4m/hr = \frac{0.4}{60x60} m/hr$$

$= 1.11 X 10^{-4} m/s$

Area required $A = Q/S_o$ Where A = tank area

Q = discharge rate

S_o = overflow rate.

$$= \frac{5.787x10^{-3}}{1.111x10^{-4}} \text{ m}^2$$

$$= 52\text{m}^2$$

L:B = 6:1 = 18 : 3

X : 6x = 52

$6x^2 = 52$

$x^2 = 52/6$

$$x = \sqrt{\frac{52}{6}} = 2.9 \text{ Approx to } 3 = B$$

Therefore: 3_m X 6_m = 18_m = L

<u>1st trial</u>

L = 18m, B = 3m, H = 1.5m (Assumed)

Where L = Length of tank, H = Height of tank (depth)

B = Breadth of tank, V = Volume

Vol = V = L X B X H

= 18 X 3 X 1.5

= 81m^3

i) Detention time

$$Td = V/Q = \frac{81x24}{500} = 3.88hrs$$

3.88hrs ok since (2< Td < 6)

Where Td = detention, V = volume and Q = discharge

Froud number Fr

iv) $$Fr = \frac{V_o^2}{gR} = \frac{(0.129x10^{-3})^2}{9.81x0.75}$$

$= 0.2 X 10^{-8} \leq 10^{-5} \leq$ unstable flow.

Then, the dimensions of L,B,H,V,Td, L:B V_o_R, Re and Fr were optimized using a computer program and the value that satisfy. The design criteria below were obtained.

a) Td = 4.052 => 2 < Td < 6 o.k

b) L:B = 31.843 => [L ≤ 6 : B≥ 10] o.k

2-85:0.895

c) Re = 937.43 => Re < 2000 laminar flow o.k

d) Fr = 0.11844 X 10^{-5} => Fr < 10^{-5} flow is stable o.k

v) Scouring Velocity

$$V_S = \sqrt{\frac{8\beta(\rho_S - \rho_w)gd}{\rho_{w\varphi\lambda}}} \leq V_O$$

With β 0.05 (grain friction factor)

λ =0.03 (hydraulic friction factor0 occur if Vo < Vs.

$$V_s = \sqrt{\frac{8x0.05(2500-100)x9.81x10^{-6}}{0.03x1000}}$$

$V_s = 4.4x10^{-3}$ m/s , $V_o = 0.00214$ m/s

T_d= (81 x 24)/500

= 3.88 hrs o.k since (2 < Td : < 6)

ii) L : B = 18: 3 = 6: 1 o.k since (6 L : B 10)

iii) Reynold number, $Re = \frac{v_o R}{\nu}$

Where Vo = Q/(BH)

Vo = flow velocity

R = hydraulic radius

ν= Coefficient of dynamic viscosity

$$= \frac{5.878x10^{-3} m^3/s}{3x1.5m^2} = 0.129x\ 10^{-3}\ m/s$$

R = hydraulic radius A = wetted area P = wetted perimeter

$$R = \frac{A}{P}$$

$$= \frac{3x1.5m^2}{3x(2x1.5)}$$

$= 0.75m$

$$Re = \frac{0.129x10^{-3}m/sx0.75m}{0.9x10^{-6}m^2/s}$$

$= 107.51 \quad < 2000$ 0.k laminar

Vs > Vo => scouring will not occur at the sedimentation tank.

Allow for 0.5m for sluge settlement and 0.3m for the depth free board.

Area = L x B X (H)

= 28.5m x (0.89540.5)m x (3.31 +0.3)m

Area = 28.5m x 1.395m x 3.61m

Volume = 143.52 m^3

A copy of the optimized program is shown in table-

Table5: Optimization of sedimentation tank design

opimization of sedimentation tank design

L	B	H	V	Td	L:B	Vo	R	Re	Fr
20.0	2.5	1.6	77.5	3.7	8.0	0.000359	0.691964	275.8585	1.89643E-08
20.5	2.5	1.7	87.5	4.2	8.2	0.000397	0.721293	317.8692	2.22319E-08
21.0	2.4	1.8	91.0	4.4	8.8	0.000437	0.72069	350.2132	2.70543E-08
21.5	2.3	1.9	94.2	4.5	9.4	0.000482	0.716836	383.6023	3.29852E-08
22.0	2.2	2.0	97.1	4.7	10.0	0.00053	0.709887	417.9862	4.03247E-08
22.5	2.1	2.1	99.5	4.8	10.7	0.000583	0.699992	453.3175	4.947E-08
23.0	2.0	2.2	101.4	4.9	11.5	0.000641	0.687288	489.552	6.09534E-08
23.5	1.9	2.3	102.9	4.9	12.4	0.000705	0.671903	526.6481	7.54982E-08
24.0	1.8	2.4	103.8	5.0	13.4	0.000777	0.653961	564.5666	9.41004E-08
24.5	1.7	2.5	104.2	5.0	14.5	0.000857	0.633574	603.2709	1.18154E-07
25.0	1.6	2.6	104.1	5.0	15.7	0.000947	0.610851	642.7264	1.49645E-07
25.5	1.5	2.7	103.3	5.0	17.1	0.001049	0.585893	682.9004	1.91459E-07
26.0	1.4	2.8	101.9	4.9	18.6	0.001166	0.558795	723.7623	2.47884E-07
26.5	1.3	2.9	99.9	4.8	20.5	0.0013	0.529649	765.283	3.25459E-07
27.0	1.2	3.0	97.1	4.7	22.6	0.001458	0.498538	807.4351	4.34447E-07
27.5	1.1	3.1	93.6	4.5	25.1	0.001644	0.465543	850.1928	5.91521E-07
28.0	1.0	3.2	89.4	4.3	28.1	0.001867	0.430742	893.5315	8.24869E-07
28.5	**0.9**	**3.3**	**84.4**	**4.1**	**31.8**	**0.00214**	**0.394205**	**937.4281**	**1.18447E-06**
29.0	0.8	3.4	78.6	3.8	36.5	0.002482	0.356001	981.8606	1.76425E-06
29.5	0.7	3.5	72.0	3.5	42.4	0.002923	0.316196	1026.808	2.75376E-06
30.0	0.6	3.6	64.4	3.1	50.4	0.003511	0.27485	1072.251	4.57218E-06
30.5	0.5	3.7	56.0	2.7	61.6	0.004337	0.232021	1118.17	8.26508E-06
31.0	0.4	3.8	46.7	2.2	78.5	0.005582	0.187767	1164.548	1.69151E-05
31.5	0.3	3.9	36.3	1.7	106.8	0.00767	0.142138	1211.368	4.21927E-05
32.0	0.2	4.0	25.0	1.2	164.1	0.0119	0.095186	1258.613	0.000151665
32.5	0.1	4.1	12.7	0.6	342.1	0.025036	0.046957	1306.268	0.001360728
33.0	0.0	4.2	-0.7	0.0	-6600.0	-0.48727	-0.0025	1354.319	-9.675293773
33.5	-0.1	4.3	-15.2	-0.7	-319.0	-0.02375	-0.05315	1402.752	-0.001082261
34.0	-0.2	4.4	-30.7	-1.5	-165.9	-0.01245	-0.10494	1451.553	-0.000150546
34.5	-0.3	4.5	-47.5	-2.3	-113.1	-0.00856	-0.15784	1500.71	-4.72914E-05
35.0	-0.4	4.6	-65.3	-3.1	-86.4	-0.00659	-0.2118	1550.21	-2.08832E-05

Coagulation and flocculation

"Coagulation is the process in which chemicals like Fe and Ai – Salts are added to water in order to transform the impurities (colloids, suspended mater, phosphate and heavy metals) after reaction with the hydrolyzing salts into large flocs which can be removed efficiently by sedimentation and filtration.

(Coagulation + Flocculation) + (_Sedimentation) + (Filtration) (RSF)

Often the combination of the Sedimentation unit operation is called the "coagulation process". Below, the flow sheet of the coagulation process is given:

⇨ | FLASH MIXING | – | FLOCCULATION | – | SEDIMENTATION | – | RSF |

(coagulation)   can be housed in block

Chemicals with positive charges are used but Aluminum salt should be used, because of its availability.

$Al_2 (So_4)_3$ -------> $2Al^{3+} + 3\ So_4^{2-}$

$Fe\ Cl_3$ ----------> $Fe^{3+} + 3cl^-$

And the P.H Correction is essential:-

Al^{3+} + $3H_20$ <---------> $Al(OH)_3$ + $3H^+$

Due to $3H^+$ ions, water will become acidic (PH) after coagulation and this can hinder the reaction of Al^{3+} ions if not controlled. The following are the optimum ranges of PH for dosage of different coagulations.

a) Al^{3+} : 6 – 7.5

b) Fe^{3+} : 4 – 10

c) Fe^{2+} : > 8.5

PH of water with low Alkalinity for surface waters usually has to be increased before the dosage of coagulations e.g by addition of lime

$$Ca(OH)_2 + HC0^-_3 \text{ -----> } Ca\,C0_3 + H_2O + OH^-$$

Hydrated lime   Reacts with H^+ :. PH

Rapid Mixing Units:

They are very important in flocculation process, chemicals have to be mixed very fast because the time of hydrolysis and charge neutralization is very short and is usually completed within a few seconds only.

Chemicals are fed at hydraulic jump

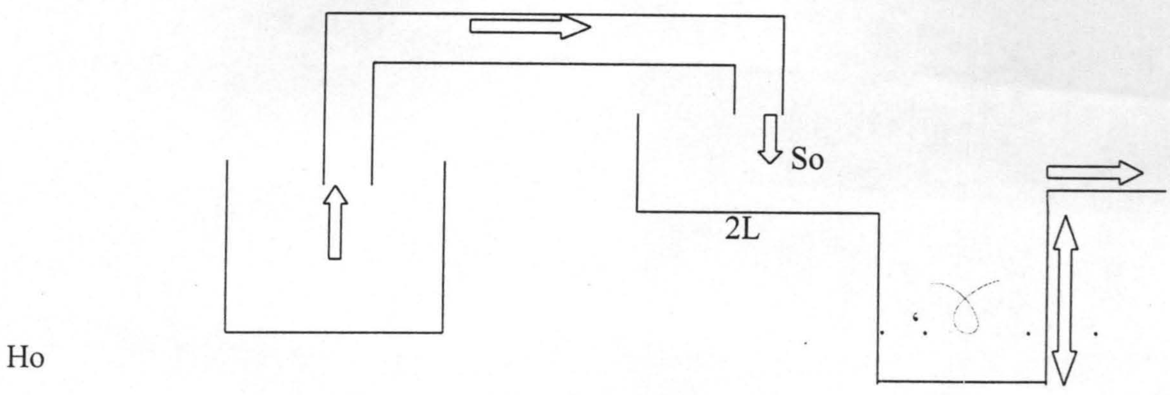


Fig. Floc. Tank

Where Ho = Height of Coagulation Tank

So = Overflow rate

L = length of tank (same as that of sed. Tank)

Td = detention time

Ho = So x Td = (0.4)m x 4hrs

= 1.6

Chemical Dosage

This is usually Aluminum Sulphate or (Alum) $Al_2 (So_4)_3 . (14\text{-}18) H_2O$ because is the common coagulant in water treatment.

Alum demand calculation:

Water requirement = $500m^3/d$

Optimum dosage rate = $10g\ Alum/m^3$ = 10mgAlum/litre

Daily Alum demand = $500x10^3x10x10^{-3}$

= 500000x0.01

= 5000g – 5kg

That is 5kg of Alum is required per day.

Calculation of size of solution container.

Vsol = Total weight of Alum

Conc. Of dosing solution

Conc. Of dosing solution. = 10g Alum/litre

Assume Pw = 1kg/litre (1000kg/m^3)

1 litre of water = 1000g

10g. Alum/litre = 10g/1000g

$$\text{Conc.} = \frac{10 \times 100}{1000} = 1\%$$

Therefore,

$$\text{Vsol} = \frac{5000\text{g}}{10\text{g/litre}} = 500\text{litre(s)}$$

That is, Solution Container = 500litres x 01unit, provide 700litre Solution Container, such that 200litre will be overboard.

Rate of flow of Solution Container =

$$\frac{\text{Vsol}}{\text{Td}}$$

Where Vsol = Volume of Solution Container

Td = detention time

$$= \frac{500 \text{ litres}}{4.025\text{hrs}} = \frac{500}{4.025 \times 60}$$

$= 2.07$litres/min.

3.6.3 Design of Filter Box

The following assumptions are upheld for the filter box design from previous works.

1) Filter box will be constructed of sandcrete blocks.

2) The filtration tank will be rectangular in shape

3) It will be build above the highest groundwater tank

4) A dimension of 0.2m, 1m, 1m and 0.3m were adopted freeboard, supernatant, sandbed and sand/filterbed area respectively.

3.6.4 Filtration Box Dimensions

Total water requirement = 500m3/d

If filtration box will work for 8hours per day, water into the system

$= 500/8 \ m^3/hr \quad = 62.5m^3/hr$

$Q = 62.5m^3/hr$

Filter dimension = L X B X H

Where; L = filter length, B = filter breadth and H = filter height

Assume H = 1m, then

$V = L X B X H = 62.5m^3$

$V = L X B X 1m = 62.5m^3$

Therefore $L X B = 62.5m^2$

If $L = B$ then $L^2 = 62.5m^2$

$L = 7.9m$

Assume that $L = 5m$

Then $B = 62.5/5m = 12.5m$

Therefore filter dimension = 5m X 12.5m X 1m

3.6.5 Filter media

the filter media thickness should be less than 0.6m, when resanding becomes necessary.

The following were considered optimum for the media material

a) The uniformity coefficient, $U_C < 2\text{-}3$

b) $d_s = d_{10}$ = effective diameter = 0.15-0.35m

c) The filter media should be free from organics, clay, loams and silt (should be clean) preferably river bed sand.

3.6.6 Filter Bottom

The filter bottom should be made of bricks with 8mm thick joints.

The filter bottom media were adopted with the following criteria:

1) $d_{90}/d_{10} <= 2^{1/2} = 1.41$

2) The minimum thickness of individual gravel layers: finer layers 5-7cm and coarser ones 8-12cm

3.6.7 Chlorination

The chlorination system adopted is a post chlorination system i.e. at the end of treatment process. This is safe guard chlorination to hub residual chlorine in the distribution system.

3.6.8 Chlorine Dosage

Chlorinated lime (Bleaching powder or chloride of lime) $CaCl_2 .CaO .3H_2O$ which is available in Nigeria will be used for the chlorination. They are usually in 40-50kg drums.

3.6.9 Contact Time

The dosage and contact time adopted are

1) 1.5mg/ l

= $500m^3/d$ = 500,000l/d

therefore the quantity of chlorine required

= V X Dosage

= 5000001 X 1.5mg/l

= 750000mg

= 0.75kg/day

the contact time = 20 – 30 minutes, therefore 30minutes was adopted

outflow rate = Q / contact time

= $500m^3/0.5hr$

= $1000m^3/hr$

= $16.67m^3/min$

3.6.10 Sizing of clear water tank

The clear water tank should be cylindrical in shape. The detention time in clear water tank should normally be 2hours

Assuming the rate of flow to the reservoir is $1000m^3/day$. The reservoir can safely detain 3sets of flows at 2hours interval before pumping

Flow rate = $1000m^3/3 = 333.3m^3/set$

Volume of tank = 334m (design volume)

Since tank will be cylindrical

$V = \pi r^2 h$

If r = h

$V = \pi r^3$

$r = 3 V/\pi = 4.73$

Let r = 5m

h = m = 6m

Actual $V = \pi r^2 h = \pi (5)^2(6)$m

$= 471m^3$

3.6.11 Sizing of reservoir tank

The reservoir tank will be overhead and situated at the highest elevation closest to the community. The tank will be designed to take care of the population requirement for at least 3days, even if the treatment plant is not working.

Water requirement $=500m^3/day$

Water requirement for 3days = 3 X $500m^3/day$

$= 1500m^3$

The tank can be cube of galvanize iron material

$V = 1500m^3$

$V = L^3$

$l = 1500^{1/3}$

$= 11.447m$

Adopt l =11.5m

Adopt a dimension of 11.5m X 11.5m X 12m, allowing for a freeboard of 0.5m

Actual volume of reservoir tank

$V = 11.5m \times 11.5m \times 12m = 1587m^3$

CHAPTER 4

4.0 RESULTS AND DICUSSION

4.1 Result and Analysis of Questionnaire

Fifty questionnaires were distributed to various categories of resident in Izom town, most of the respondents were farmers, and others are artisans and students or staff of science college Izom.

From the analysis of the questionnaire, it shows that sixty five percent of the respondents have greater than five persons in the household, while the others are between two to four people per household.

The quantity of water used per person per day varies from one social class to the other. Eighty five percent of the respondents use between forty to fifty litres per capita per day, while the rest averages about sixty litres per capita per day. One hundred percent of the respondents use the Izom river water for one purpose or the other. Forty percent of the respondents have wells or source their water from wells. It is only in Izom Science College that thirty percent of the respondents source their water from borehole.

Ninety five percent of the respondents were not satisfied with the quality of the water they were using for drinking, cooking or laundry. They complained of the water being muddy during the rainy season and fairer during the dry season, though has no taste during the dry season. Sixty percent of the respondents cover a distance of about thirty to five hundred meters to get water.

Sixty five percent of the respondents said that at least a member of the family has been struck by Cholera or Diarrhea while ten percent reported Scabies.

One hundred percent or all the people supported the construction of a treatment plant and promise to be able to pay for water rate if the prices are moderate. A sample of questionnaire is shown in appendix A.

4.2 Water Quantification Results

The flow rate of Gurara river at Izom were analysed to determine whether or not the river can satisfy the water requirement of Izom town till 2020.

From table _

Table6 :Mean flows in Gurara river 1989—1990

Year	Month	Sum m^3/s	Mean m^3/s	Meanm^3/d
1989	Jan	15.72	0.524	4527.6
	Feb	12.59	0.419667	36259.2
	Mar	8.26	0.275333	23788.8
	April	6.39	0.213	18403.2
	May	25.77	0.859	74217.6
	June	39.85	1.328333	114768
	July	36.65	1.2211667	105552
	Aug	82.01	2.733667	236188.8
	Sept	90.38	3.012667	260294.4
	Oct	52.07	1.735667	149961.6

	Nov	22.55	0.751667	64944
	Dec	15.99	0.533	46051.2
1990	Jan	10.15	0.338	29232
	Feb	5.07	0.169	14601.6
	Mar	4.01	0.134	11548.8
	April	8.86	0.295	25516.8
	May	40.54	1.351	116755.2
	June	44.13	1.471	127094.4
	July	57.54	1.918	165715.2
	Aug	81.21	2.707	233884.8
	Sept	45.4	1.513	130752
	Oct	86.18	2.872	248198.4
	Nov	64.83	2.161	186710.4
	Dec	49.87	1.663	1403625.6
			MIN	11548.8
			MAX	260294.4
			MEAN	108722

The mean flow from January to December for the year 1989-1990 shows that the minimum flow per day for those two years is 11,584.8m^{3}per day. The mean was 108,722m^3; the maximum flow was 260,294.4m^{3}per day. The design water requirement up to 2020AD for the projected population was 500m^3 per day. This implies that even with the minimum flow there will be an excess of 11,048.8m^3 per day.

An intake at Gurara river will be able to satisfy the water requirement of the people even without a weir a reservoir Dam being constructed.

4.3 Results of Water Quality Analysis

The results of physical and chemical analysis are presented in tables 7 and 8.

Table7:Results of Physical Properties of water Samples

	PARAMETER	SAMPLE1	SAMPLE2	SAMPLE3
1	Taste	unobjectionable	unobjectionable	unobjectionable
2	Colour	light yellow < 70Haen unit	light yellow < 70Haen unit	light yellow < 70Haen unit
3	Odour	Chloroform	Chloroform	Chloroform
4	Turbidity	9.8 JTU	11.3 JTU	11.5 JTU
5	Total Solids	520ppm	600ppm	580ppm
6	Total Dissolved Solids	270ppm	320ppm	322.5ppm

7	Temperature	28^0C	26.5^0C	26^0C

Table8: Results of Chemical Analysis of Water samples

	PARAMETER	SAMPLE 1	SAMPLE2	SAMPLE3
	pH	8	7.8	7.6
	Total Alkalinity	45ppm	49ppm	40ppm
	Acidity($CaCO_3$)	5ppm	3.9ppm	4.8ppm
	Chlorides (Cl)	3.2ppm	2.9ppm	2.8ppm
	Alkalinity	43ppm	40ppm	41ppm
	Total Hardness	82ppm	90ppm	84ppm
	Calcium Hardness	31ppm	24ppm	32ppm
	Total Iron	0.18ppm	0.12ppm	0.09ppm
	Nitrate	0.09ppm	-	0.05ppm

Bacteriological Analysis:

All the water samples are contaminated (MPN> 16) the water is therefore not fit for human consumption.

The contamination is confirmed due to the presence of coliform bacteria in the water.

The presence of coliform is an indication that the water is contaminated and may contain other pathogenic micro organisms, thus there is the need for the water to be treated properly for it to be fit for human consumption. From the results of physical analysis, it shows that the colour of the water is objectionable, it has a chloroform odour, but the taste is okay. The total dissolved solids indicate that the water is polluted.

The chemical analysis indicates that there is the presence of iron in the water, however this is not above the WHO standard of 0.3ppm. The bacteriological analysis indicate that the water is highly polluted. The water will therefore require more treatment to make it potable.

4.4 Design Summary

A summary of the design of the treatment unit are given below.

1. Sedimentation Tank

Dimension 28.5m X 1.395m X 3.61m

Volume 143.52m^3

Detention time 4hours

Scouring velocity Vs = 4.4x 10^{-3}

2. Coagulation and Flocculation

Hydrated lime and Aluminium sulphate $Al_2(SO_4)_3$

3. Rapid Mixing Unit

Detention time 4hours

Overflow rate 0.4m/s

Chemical dosage 5kg of Alum per day

Solution container of 700litres

Detention time of the chemical dosage 2.07litres/m

4. Filtration

Filter dimension 5m X 12.2m X 1m

5. Chlorination

Post chlorination will be adopted

Chlorine form: chlorinated lime $CaCl_2 . CaO . 3H_2O$

Contact time $16.67m^3/min$

6. Clear Water Tank

Dimension: it will be cylindrical in nature with a dimension of 5m dia and 6m height

7. Reservoir Tank

Dimension 11.5m X 11.5m X 12m

Material of construction: Galvanize iron

A diagram of the designed treatment plant is shown in figure4

See appendix B

Fig4 : Diagram of the design 500m^3/day treatment plant for Izom community

CHAPTER 5

5.0 CONCLUSION AND RECOMMENDATIONS

5.1 CONCLUSION

Izom community is a typical rural settlement in Niger State of Nigeria. They are blessed with surface water resources since Gurara river at Izom flow through the town. It has a minimum flow of over 11,000m^3 per day and the total water required by the population upto the projected year 2020AD was estimated to be below 500m^3 per day. Development of the surface water resources of the community become economical and feasible.(Linsley et al. 1990).

The quality of the water does not satisfy the WHO requirement for potable water, a unit treatment system of 500m^3 capacity, which is cost effective and efficient, was designed for the Izom community. The treatment system will be found useful if implemented.

5.2 RECOMMENDATION

The government or the community should ensure that the surface water resources of the area should be developed, by constructing the designed mini treatment plant.

APPENDIX A

SAMPLE QUESTIONNAIRE

Federal University of Technology, Minna.

Department of Agricultural Engineering

This Questionnaire is design to seek information from you on designing a mini water treatment plant for Izom community.

RESPONDENT INFORMATION

Age…………………

Sex…………………

Area of Resident in Town ……………………………………………………

Number in the Household……………

Quantity of water used per person per day………………………………………

Source of water, river…………well………borehole……………

Colour of water, clear………fair…………muddy…………

Taste of water, tasteless……………fair………………tasty………

What distance do you cover to get water………………………

Which of these diseases have struck a member of the family before,

Cholera…………diarrhea…………scabies………………guinea worm…………

Will you support the construction of a treatment plant Yes…….. No…….

Can you pay for water rate if the plant is commissioned Yes……….No…….

APPENDIX 2

COMPARISON OF WATER QUALITY ANALYSIS RESULT WITH THE WORLD HEALTH ORGANIZATION STANDARD

S/NO	parameter	sample1	sample2	sample3	WHO highest desirable concentration
1.	Taste	unobjectionable	unobjectionable	unobjectionable	*
2.	Colour	Light Yellow < 7Hazen units	Light Yellow < 7Hazen units	Light Yellow < 7Hazen units	<5Hazen units
3.	Odour	Chloroform	Chloroform	Chloroform	+
4.	Turbidity	9.8 JTU	11.3 JTU	11.5JTU	5 JTU
5.	Total solids	520ppm	600ppm	580ppm	500ppm
6.	p^H	8	7.8	7.6	6.5-8.5
7.	calcium hardness	31ppm	24ppm	32ppm	200ppm
8.	chlorides	3.2ppm	2.9ppm	2.8ppm	200ppm
9.	iron	0.18ppm	0.12ppm	0.09ppm	0.3ppm

- * unobjectionable (threshold number < 2)
- + unobjectionable (threshold number < 2)
- = no recommendation made, but values are reasonable.

CONVERTION TABLE	
1ppm =	1mg/L
1JTU =	2.5 NTU

A SKETCH OF THE DESIGNED WATER TREATMENT PLANT