"Mini Water Plants (MWP) and the Pressure Filter System (PFS) – A Sustainable Water Treatment/Supply Strategy for Rural Nigeria"

Prof. Engr. C.W. Adegoke, Ph.D., PE, MNSE, Reg. COREN
Geo-Environmental Specialist Consultant
+234-703-939-3221; pfsdallas@gmail.com

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Abstract
*Nigeria lies between Longitudes 2° 49'E and 14° 37'E and Latitudes 4° 16'N and 13° 52' North of the Equator. The climate is tropical, characterized by high temperatures and humidity as well as marked wet and dry seasons, with slight variations between South and North. Total rainfall decreases from the coast northwards with annual rainfall ranging between 1,500 and 4,000 mm for the south and between 500 and 1000 mm for the extreme North. This paper examines Nigeria's hydrology and inland water resources potential and concludes that Nigeria is blessed with a vast expanse of inland freshwater and brackish ecosystems. In spite of these enormous freshwater resources (which waste and flows into the ocean annually as surface runoff), the rural populace which constitute about 65% of Nigeria's population still lack adequate safe drinking water and sanitation. Despite the fact that the United Nations declared **1980-1990 as "Water and Sanitation Decade"** with a goal to provide safe water and sanitation for all before 1990, this goal remains a mirage for Nigeria several decades afterwards. The paper posits that our rural water supply challenge is more of **"Water Quality"** rather than **"Water Quantity"** issue. It therefore presents the Mini Water Plants **(MWP)** and Pressure Filtration System **(PFS)** as a more sustainable water treatment technology option that can harness the abundant inland fresh water resources and make safe drinking water available to the rural populace at a shorter project gestation period. The raw water quality of the rural waters are not as highly polluted as the urban waters since there is less industrial pollution activities in the rural areas; the waters therefore require lighter treatment technologies to render them potable as opposed to urban water treatment which requires construction of large concrete Rapid Gravity Sand Filtration **(RGSF)** infrastructures. For the rural areas, attention should be placed on mobilizing MWP's and PFS systems to treat surface waters and springs which are locally available within the communities and involve the Community Development Associations (CDA's) and WASHCOM in the maintenance of such water facilities. By so doing, Nigeria will rapidly evolve from the current scenario of **"Water, Water, Water Every Where and Yet No Drop to Drink!".** It is only then that its quest to obtain the **Guinea worm-free Certification** from WHO at the end of this year may become meaningful and sustainable.*

Key words: *hydrology, inland water resources, water quality, mini water plants, pressure filter systems*

1.0 Introduction
The importance of water to any community's development cannot be over emphasized since it has become one of the most serious limiting factors in development around the world and is assuming almost a strategic importance with oil.

The out-gone decade 1980-1990 was declared by the United Nations as the 'Water and Sanitation" Decade to provide safe water and adequate sanitation for all before the year 1990; however, at the end of the decade and several decades after, this laudable goal still remains a mirage for Nigeria. Majority of her citizens still rely on polluted localized water sources such as ponds and deep shallow wells infested with schist, flukes, guinea-worm and other disease-causing organisms [9].

In an attempt to achieve the goal of water for all in the last decade, government stepped up its effort by sinking Boreholes in many parts of the rural areas all over the country [2], [3]. This attempt has met with partial success due to reasons ranging from low yields as a result of limiting geologic conditions to inadequacy in the present level of technology awareness and institutional capacity in the rural areas for sustaining the required Operational Maintenance and Management service programme (OMM) necessary for continual functionality of the boreholes. The partial success with the borehole experiment and especially the current high cost (due to inflation) of construction and management of boreholes have left, administrators wondering on which other available water supply strategy option to be pursued. Most of the rural communities in Nigeria have perennial sources of surface water supply close to the community in form of water table effluent ponds, springs, streams, and rivers. A recent rural water survey in Osun state, confirms that most villages are located within 250metres of a perennial water source [8]. It is also pertinent to note that Fadama land with perennial water also abound in most parts of the Northern states. The only limiting factor is the poor quality of this water which could be harnessed through cheap and economic methods that are devoid of complicated maintenance operations as in the conventional urban water schemes. Thus the national rural water challenge is more of a **'Quality'** than **'Quantity'** issue.

It is against the above background that the proposal to install some units of **Mini-Water Plants (MWP)** using Pressure Filtration System (**PFS**) in all the local government areas of the federation which have access to perennial surface water sources is being presented.

2.0 Hydrology of Nigeria

The hydrology of Nigeria is dominated by two great river systems, the Niger-Benue and the Chad systems. With the exception of a few rivers that empty directly into the Atlantic Ocean (Cross River, Ogun, Oshun, Imo, Qua Iboe and a few others), all other flowing waters ultimately find their way into either the Chad Basin or down the lower Niger to the sea. The distribution of the major inland water bodies of Nigeria is shown in Figure 1 (including the 8 Hydrological Areas).

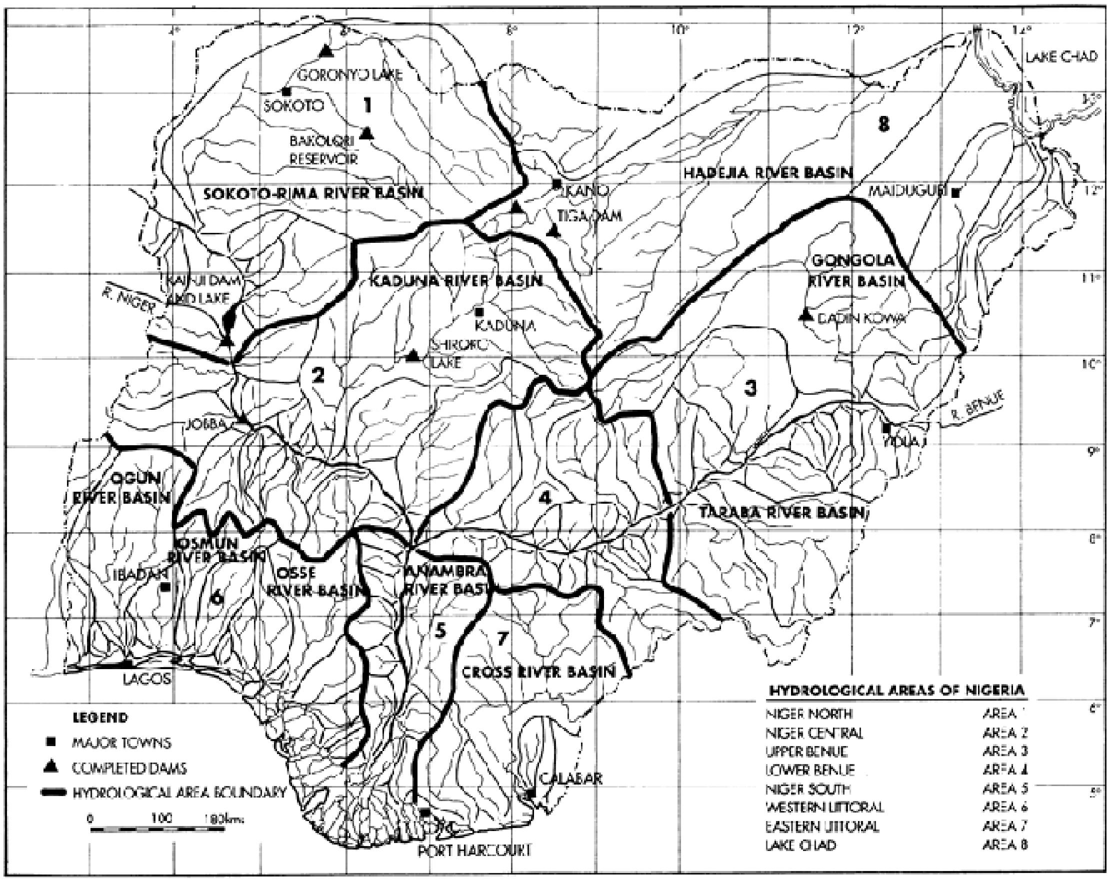


Fig. 1. Hydrological map of Nigeria showing the major inland waters

The two river systems (Niger-Benue and Chad) are separated by a primary watershed extending north-east and north-west from the Bauchi Plateau which is the main source of their principal tributaries. North-west of the plateau lie the elevated, drift-covered plains of central Hausa-land which is drained by numerous streams all flowing outwards to join the major tributaries.

The rivers flowing into Lake Chad emanate both from the central highland and from the high plateau and converge to form the Yobe River just before flowing into Lake Chad. Some rivers flowing into the lake originate from the Cameroon mountains. Only a small part of Lake Chad lies within Nigeria. Along the Nigerian border, the lake is little more than a vast swamp. A few passages are cut through the reeds and tall grasses for movement of canoes to open water.

Within Nigeria the River Niger is fed by rivers flowing into it from all directions with headwaters originating from the central plateau in the north, from the Yoruba highlands in the south, from Benin Republic to the west and from the eastern highlands. A significant flow from outside Nigeria comes from the watersheds stretching westwards right up to the

Fouta Djallon mountain of Guinea. The River Benue is fed by rivers emanating both from the high central plateau and also from the Cameroon mountains and Ogoja hills.

Of the other rivers flowing to the Atlantic, the Cross River is fed by many tributaries originating in the Cameroon mountains. It flows east and then turns southwards and empties into the Atlantic Ocean with limited delta formation. Both the Ogun and Oshun rivers are fed by rivers originating from the Yoruba highlands. They flow slowly from north to south into the Lagos lagoons before discharging through creeks and swamps into the Atlantic Ocean. Other rivers flowing into the Atlantic Ocean in the south include; Imo, Kwa Iboe, Ase, Orashi, Benin and numerous creeks in the Delta and Rivers States areas.

3.0 Inland Water Resources of Nigeria

Nigeria lies between Longitudes 2° 49'E and 14° 37'E and Latitudes 4° 16'N and 13° 52' North of the Equator. The climate is tropical, characterized by high temperatures and humidity as well as marked wet and dry seasons, though there are variations between South and North. Total rainfall decreases from the coast northwards. The South (below Latitude 8°N) has an annual rainfall ranging between 1,500 and 4,000 mm and the extreme North between 500 and 1000 mm.

Nigeria is blessed with a vast expanse of inland freshwater and brackish ecosystems. Their full extent cannot be accurately stated as it varies with season and from year to year depending on rainfall. However, as shown in Figure 1 these water resources are spread all over the country from the coastal region to the arid zone of the Lake Chad Basin.

The country has an extensive mangrove ecosystem of which a great proportion lies within the Niger Delta and are also found mostly in Rivers, Delta, Cross River, Akwa Ibom, Lagos and Ondo States. They lie between Latitudes 3° and 7° 6' North and are estimated to cover between 500,000 and 885,000 ha. Freshwaters start at the northern limit of the mangrove ecosystems and extend to the Sahelian region.

The major rivers, estimated at about 10,812,400 hectares, make up about 11.5% of the total surface area of Nigeria which is estimated to be approximately 94,185,000 hectares.

Thirteen lakes and reservoirs with a surface area of between 4000 ha and 550,000 ha have a total surface area of 853,600 ha and represent about one percent of the total area of Nigeria [4].

The water bodies are divided into saline deltas and estuaries, and freshwaters. Deltas and estuaries, with their saline wetlands have a total surface area of 858,000 ha, while freshwaters cover about 3,221,500 ha. Other water bodies, including small reservoirs, fish ponds and miscellaneous wetlands suitable for rice cultivation cover about 4,108,000 ha.

Thus the total surface area of water bodies in Nigeria, excluding deltas, estuaries and miscellaneous wetlands suitable for rice cultivation-but not necessarily suitable for fish cultivation, is estimated to be about 14,991,900 ha or 149,919 km^2 and constitutes about 15.9% of the total area of Nigeria [3].

4.0 Design Philosophy and Strategy of the Mini-Water Plants (MWP's)

The general philosophy guiding the design is to build functional, reliable and safe system at a minimum initial and running (maintenance) cost.

The philosophy of approach which motivates this concept of Rural Water Supply strategy is based on the following cardinal points:-

i) 65% of Nigeria populace abide in the rural areas

ii) Recent efforts of government and World Bank in addressing water problems are presently directed to urban areas (National Water Rehabilitation Projects refers).

iii) Hydrologically, Nigeria is blessed with a good amount of annual rainfall (varying between 1,500mm to 4,000mm in the south to between 500mm to 1,000mm in the far north) which ironically wastes away every year as **run off** emptying into the ocean through a network of rivers, rivulets, springs and ponds scattered throughout the rural communities; thus the adage **"Water, Water, Every where and yet No Drop to Drink"** becomes relevant.

iv) Most rivers in the rural areas are not as heavily polluted as urban rivers (which carry more industrial pollution) since there is less industrialization and therefore less pollution and the waters require only **minimal treatment** to render them potable.
Thus the normal treatment processes required for urban waters such as Aeration, Coagulation, Flocculation, Sedimentation, Filtration and Disinfection may **NOT ALL** be necessary for rural waters:- **Sedimentation** plus **Filtration** are known to be capable of removing turbidity and 90% pathogens from water.

v) Most rural communities in Nigeria are located within 250metres of a perennial source of water, stream, pond, springs, etc; since the decision to settle in any area by the founding fathers have always been predicated on the availability and existence of easily accessible water source, the only limiting factor being the potability of such waters. (Please note that even in some parts of Northern Nigeria, wetlands and FADAMAS exist in some places!).

vi) The Nigeria's Rural Water problem is more of a **"Quality Problem"** rather than a **"Quantity Problem"**. Therefore rather than divesting energies in developing **new sources of water supplies** such as boreholes why not improve the Quality of Naturally Endowed Waters **located in each community** through simple water treatment technologies? The Guinea-worm scourge became prevalent nationwide NOT due to lack of water in such communities but due to lack water **free from Guinea-worm Cyclops**- then the simplest form of intervention measures is to devise means of removing the causative agent from the water through FILTRATION and not to develop new sources of water supply for such communities.

vii) Provision of Mini Water Plants in all Rural Communities based on surface water (River, Stream, Pond or Spring) and packaged Water Treatment Plant (WTP) using compact pressure filters [1], will meet the desirable outcome nation wide.

viii) This project of "Mini Water Works" in all rural communities Nationwide scores a **Bull's Eye** in meeting the above objective and will constitute an obvious deviation from the previous government's approach of investing on "White Elephant " large sinlge-scheme projects (which most times are unsustainable). Instead, many de-centralized small mini schemes which can be easily maintained and sustained are recommended as a more sustainable approach. **(Sustainable Development)**

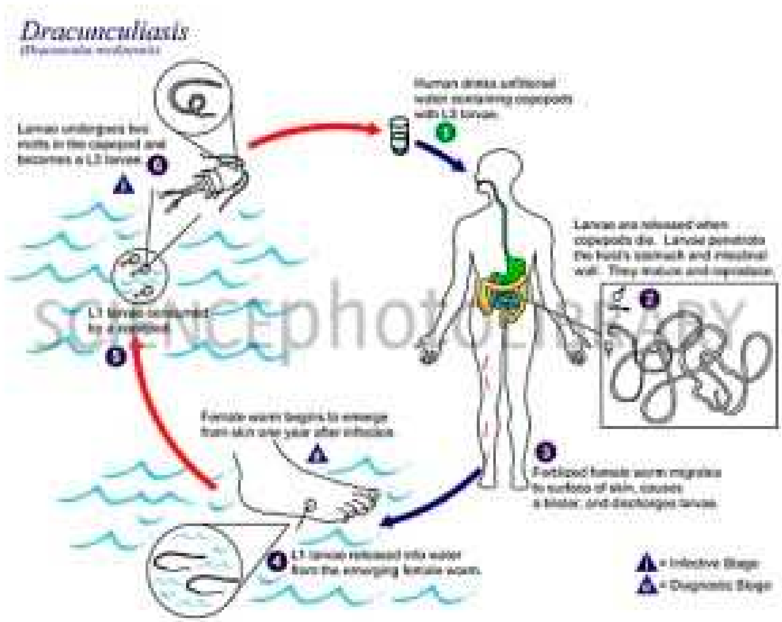


Fig. 3: The Guinea-worm Life Cycle

4.1 Design Concept

In the Pressure Filter System, raw water is forced by means of a centrifugal pump, through one or a set of pressure vessels or tanks charged with appropriate geologic/synthetic filter media which filters, corrects the PH and removes taste/odor from the raw water thus rendering it potable. The system has a lot of advantages over conventional rapid sand filtration system and its portability and flexibility particularly makes it more versatile and appropriate for rural water supply applications [1],[10].

Generally, the application of the pressure filter system in providing potable water for any community or geographical area involves:

(i) A survey and identification of the various communities' existing sources of water supply (e.g. Springs, Perennial rivers, lakes, water-table effluent ponds, etc) [8].

(ii) Protecting and improvement of the source intake by expanding it into an infiltration gallery or diversion channel.

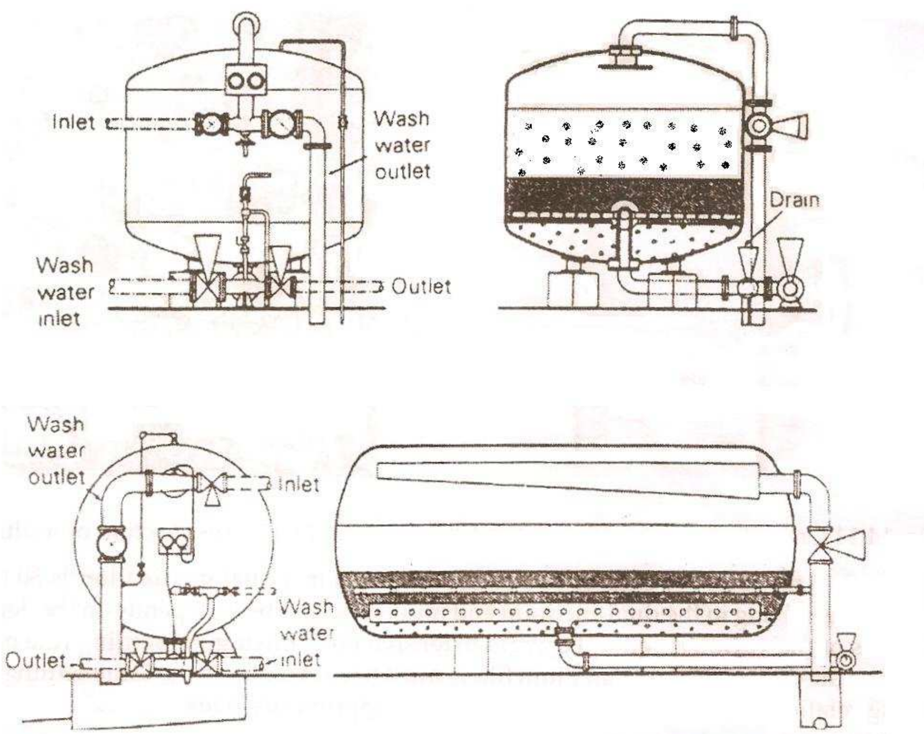
(iii) Direct Abstraction (pumping) by means of petrol, diesel, or solar-powered centrifugal pump (Low-Lift) through some lengths of UPVC pipes into a Clarifier Unit/Sedimentation Tank – (a Spray Bar or Aeration Chamber plus addition of appropriate flocculating chemicals such as alum are added as necessary at this point depending on the raw water quality) – a second pump (High-Lift) takes the water through the pressure filtration system located at a central point close to the consumers (post chlorination or Ultra violet disinfection can be applied at this point as necessary. As long as the raw water goes through the filtration system, it then becomes potable and completely free of sediments/guinea-worm infestation.

(iv) This then becomes a simple practical cost effective means of combating the guinea-worm scourge nationwide.

It is pertinent to note that the approach de-emphasizes the development of new water schemes like boreholes etc, but encourages upgrading the existing water sources in the various communities to minimize capital expenses. However, in areas where the existing water sources are inadequate, new schemes would have to be developed.

The Pressure Filter Option

Most existing water treatment scheme utilizes a sand filter bed in a rectangular open surface concrete enclosure to remove suspended solids in water (Rapid Gravity Sand Filtration System- RGSF) but a more viable option is the **Pressure Filter System**. (PFS) [1], [10].



Pressure filters. Top: Vertical pressure filter, Bottom: Horizontal pressure filter

Fig 2: Pressure Filter System (PFS)

The pressure filter system requires the pumping of water through the bed under pressure [1]. The pressure filter tank along with an aeration tank is capable of treating a large range of water pollutants. The pressure tanks exist in several sizes which make their adaptability versatile. Thus they are capable of being used in locations requiring both large or small quantities of treated water such as in industries, town water supply, domestic use, swimming pools, etc.

Applications

The pressure filter tank can be one or a set of two or three depending on the nature of the water to be treated. A mixed media bed results if only one tank is used and two layers of granular media are used. Several forms of filter media can be selected from activated carbon, calcite or silica sand. The sand helps in the treatment process by removal of silt to sand-sized particles. The average size of Guinea worm Cyclops have been found to be around 0.6mm in diameter (approximately size of a pin head) which falls within the **"fine sand"** size range and therefore is easily removed through a filtration process. A crude method of intervention has always been the traditional use of "clothe filtration". The calcite (dolomitic limestone) medium acts to correct the PH of the water while the activated carbon is employed to remove (through adsorption) the undesirable taste and odour of the water. Additional chemical treatment in form of application of chlorine tablets into the filtered water to kill other microorganisms may also be done as necessary at this point.

Components

Each pressure tank can be divided into three parts namely:

(I) Cylindrical steel tank, filter medium and screen, (ii) Pipe and valve system, and (iii) Pumping system. The cylindrical vessel is made of 6mm thick steel or 3mm stainless steel plate. A stainless screen of appropriate slot size is attached near the bottom of the vessel for the filter medium to rest on.

The pipe and valve system serve as the starting points of all operations of the filtration system. It consists of a network of pipes and valves used in the operation of the filter system be it backwashing, purging or the normal filtering operation. The pumping system consists of booster pumps which are incorporated into the filter system to boost water through the filters to storage during normal filtering operation. By appropriate manipulation of the valves backwashing operation is also easily affected. (Fig.4)

		WATER TREATMENT PROCESS OPERATIONAL CYCLE FOR MWP5.0																
OPERATIONAL MODE							VALVE NUMBER										TIME	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16		
FILTRATION	0	X	0	X	X	X	0	X	0	X	0	X	X	X	0	X	16	
BACKWASH(1)	X	0	X	0	X	X	X	0	0	X	0	X	X	X	0	X	2	
PURGE(1)	0	X	0	X	0	0	X	0	0	X	0	X	X	X	0	X	2	
BACKWASH(2)	0	X	0	X	X	X	0	X	X	0	X	0	X	X	X	0	2	
PURGE(2)	0	X	0	X	X	X	0	X	0	X	0	X	0	0	X	X	2	
CYCLE SUMMAR	FILTRATION PUMPING TIME = 16.0hrs																	W
	PUMP REST		4.0hrs															
	PURGE TIME		2.0hrs															
	PURGE TIME		2.0hrs															
LEGEND;-																		
0= OPEN (ON)																		
X = CLOSE (OFF)																		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16		
FILTRATION	1	0	1	0	0	0	1	0	1	0	1	0	0	0	1	0	16	6
BACKWASH(1)	0	1	0	1	0	0	0	1	1	0	1	0	0	0	1	0	2	6
PURGE(1)	1	0	1	0	1	1	0	1	1	0	1	0	0	0	1	0	2	8
BACKWASH(2)	1	0	1	0	0	0	1	0	0	1	0	1	0	0	0	1	2	6
PURGE(2)	1	0	1	0	0	0	1	0	1	0	1	0	1	1	0	0	2	7
FILTRATION	1	3	7	9	1	15												
BACKWASH(1)	2	4	8	9	1	15												
PURGE(1)	1	3	5	6	8	9	11	15										
BACKWASH(2)	1	3	7	10	1	16												
PURGE(2)	1	3	7	9	1	13	14											

Fig. 4: Operational Cycles of the PFS System

Filter Media

Most urban water works constructed many years ago in the country, employed imported filter media. However, in recent years high grade filter media are being produced in the country and used for packaged Water Treatment Plants.

High–grade mono-minerallic (Silica Sand) Filter media are now being produced in Nigeria.

Availability of adequate filter media to meet the demand of nation wide rural water supply schemes is therefore assured.

5.0 Technical Specifications of the Rural Mini-Water Plants (MWP)

The specification of the rural mini water plants are as follows:

(i) The Intake Works

The intake works shall consist of improving the existing surface water in the community by expanding the seepage areas through excavation and clearing it of undesirable debris: a 1.5-3HP centrifugal or solar-powered submersible pump (shall be placed on a concrete pedestal above flood level) with suction hose (fitted with a strainer) into the raw water. The pump shall have a head of 20.0m and maximum output of 27m^3/hr (6,000gph). In special situations, in the case of low flowing streams where the stream flow cannot meet with the demand in the dry season, simple impounding structures like stone (rock-fill) weirs or wooden barrages or small earthen or rock-fill dams can be built across the stream to create impounded storage.

(ii) Aeration/Coagulation/Sedimentation Tank (Clarifier Unit)

The centrifugal pump shall discharge raw water through an aeration spray bar into a 20,000litres (3.6m x3.6m x1.5m) sedimentation tank constructed on a mass concrete raft floor. The tank shall be made of concrete-filled blocks.

A one hour detention/contact period should be sufficient for clarification in the sedimentation tank.

(iii) Booster/Filter Pump

A second centrifugal pump, pump II placed on a concrete pedestal shall boost the clarified water through the pressure filters into the clear water tank. The pump shall also be a 1.5-3HP solar-powered pump.

(iv) Pressure Filters

The clarified water from the sedimentation tank, shall be boosted through 2No pressure filters charged with filter media of appropriate gradation such that the remaining suspended flocs and the guinea worm cyclops are entrapped in the interstitial spaces of the media to give a clear and w][‘\holesome treated water , Each pressure tank is a cylindrical vessel welded from 6mm thick steel plates with flanged openings for charging, discharging and recharging the filter medium. Raw water or clarified water is forced through the filter medium overlying a steel screen of a appropriate slot size into the clear water tank. Movement of water through medium, filters and imparts some chemical reaction to the water. The first shall be a de-acidizing pressure tank charged with calcite to correct the PH of water. The second tank shall be a taste/odour pressure tank charged with **Activated Carbon** to remove dissolved organic matter in the water thus improving the taste and odour.

A one meter difference in elevation between the aeration tank and the pressure filters can ensure continuous gravity flow through the filters thus obviating the need to operate pump II into the stand-pipes.

(a) **De-Acidizing Pressure Tank**

The size of the tank was 450mm dia x 1500mm high constructed with mild steel plates of 6mm complete with all valves and fittings, Fitted internally with steel screen painted internally with nontoxic anti-corrosion bituminous paint and painted extremely with coats of gloss paints. The tank was painted with bituminous paint and pained extremely with 2 coats of gloss paints. The tank will be charged with calcite filter media.

(b) **Taste/Odour Pressure Tank**
Ditto above the tank will be charged with activated carbon for removal of taste, odour and colour.

(iv) **Backwashing**
Backwashing will be desirable at least once a week. About 4% of the clear water volume will normally be required for the backwashing operations.

(v) **Clear Water Tank**
The clear water tank shall consist of 4,500 gallons (20,000 litres) -12'(3.6) x 12'(3.6m) x (1.5m) concrete or fibre glass tank supported on mass concrete raft foundation provided with outlets and discharge outlets.

(vi) **Plant Capacity**
It is assumed that a 5m^3/hr (1,000gph) plant or 10m^3/hr (2,00gph) plant should satisfy the potable water demand of most communities in the rural areas. The plant also has facilities for expansion by increasing the number of pressure filters in parallel connection.

6.0 Operational, Maintenance and Management (OMM)

The plant will be operated by a Water Treatment Plant Operator (WTPO) appointed by the Community Development Association (CDA). After installation of the rural mini water works, the running, maintenance shall be responsibility of the local government authorities (LGA's) through the respective Community Development Association's (CDA's). In fact the service of the local government shall be their own counterpart contribution to the project.

7.0 Special Features/Advantages of the Pressure Filter System

1. With only slight modification (usually on the filter medium) the pressure filter system can be designed to effect any desired water treatment requirements. For example, Magnadol, Akdolite or Green sands media can be effective for iron removal.
2. With the emphasis of the present government on rural water supply through PTF and the local Government Areas, a shift from large scale water schemes servicing limited urban areas to mini water schemes serving many villages in the rural areas become necessary alternative water resources management strategy. The pressure filter option therefore readily fulfils these objectives. Its units can be built (simply by varying the tank sizes and pump sizes) to meet a wide range of water demand ranging from say 1m^3/hr to over100m^3/hr. This is an obvious advantage over large treatment water which usually incorporates a single scheme embodying major source and treatment works with radial distribution feeding the outlying communities. With the pressure filter option, trunk distribution costs are considerably reduced as water sources and treatment works can be located near the communities obviating the need for many kilometers of medium diameter pipe work.

3. Its versatility with respect to common water contaminants and the fact that it exits in many economic sizes makes it easily adaptable for either domestic, industrial or for municipal water schemes.
4. With existing diminishing foreign exchange reserve and its attendant import problems, the pressure filter option scores a bull's eye in that 90% of its parts are manufactured locally and almost all the filter media (except for special conditions) are obtainable within the country. Also because of the simplicity of its construction, it effectively beats off maintenance costs to the lowest minimum.
5. In-built accessories allow for safe, fast and efficient cleaning operations as it is possible to disconnect a unit and generate the filter medium. It is also possible to upgrade existing small unit (when consumption rate demands) by simply connecting additional units in parallel with the existing unit. This becomes very advantageous especially in phased development considerations wherein an existing unit does not necessarily become completely valueless in the face of future expansion and growth. Figs. 4 & 5 show the Operatonal Cycle of the Mini Water Plant and the Digital Mode for Automated Valve Operation.

Hr.	Q4	Q3	Q2	Q1	QO	Hr.	6	5	4	3	2	1
0	0	0	0	0	0	0	0	1	0	0	0	0
1	0	0	0	0	1	1	0	1	0	0	0	0
2	0	0	0	1	0	2	0	1	0	0	0	0
3	0	0	0	1	1	3	0	1	0	0	0	0
4	0	0	1	0	0	4	0	1	0	0	0	0
5	0	0	1	0	1	5	0	1	0	0	0	0
6	0	0	1	1	0	6	0	1	0	0	0	0
7	0	0	1	1	1	7	0	1	0	0	0	0
8	0	1	0	0	0	8	0	1	0	0	0	0
9	0	1	0	0	1	9	0	1	0	0	0	0
10	0	1	0	1	0	10	0	1	0	0	0	0
11	0	1	0	1	1	11	0	1	0	0	0	0
12	0	1	1	0	0	12	0	1	0	0	0	0
13	0	1	1	0	1	13	0	1	0	0	0	0
14	0	1	1	1	0	14	0	1	0	0	0	0
15	0	1	1	1	1	15	0	1	0	0	0	0
16	1	0	0	0	0	16	0	0	1	0	0	0
17	1	0	0	0	1	17	0	0	1	0	0	0
18	1	0	0	1	0	18	0	0	0	1	0	0
19	1	0	0	1	1	19	0	0	0	1	0	0
20	1	0	1	0	0	20	0	0	0	0	1	0
21	1	0	1	0	1	21	0	0	0	0	1	0
22	1	0	1	1	0	22	0	0	0	0	0	1
23	1	0	1	1	1	23	0	0	0	0	0	1
24	1	1	0	0	0	24	1	0	1	0	0	0
25	1	1	0	0	1	25	1	0	1	0	0	0
26	1	1	0	1	0	26	1	0	0	1	0	0
27	1	1	0	1	1	27	1	0	0	1	0	0
28	1	1	1	0	0	28	1	0	0	0	1	0
29	1	1	1	0	1	29	1	0	0	0	1	0
30	1	1	1	1	0	30	1	0	0	0	0	1
31	1	1	1	1	1	31	1	0	0	0	0	1

FILTRATION	1	3	7	9	11	1
BACKWASH(1)	2	4	8	9	11	1
PURGE(1)	1	3	5	6	8	9
BACKWASH(2)	1	3	7	10	12	1
PURGE(2)	1	3	7	9	11	1

Legend:

Fig 5: Digital Control of the PFS System for Automated Valve Operation. (1=Open; 0=Close)

8.0 Bill of Quantities

Table 1 shows the un-priced Bill of Quantities of typical Rural Mini-water Works plant installation located in any rural community of the Federation.

TABLE 1: TYPICAL UNPRICED BILL OF QUANTITIES FOR A MINI-WATER PLANT (MWP)

ITEMS	DESCRIPTION	RATE	UNIT	QTY	COST
1	**RURAL WATER SURVEY** Carry out a Rural Water Survey in the village; estimate hydraulic parameters:- stream flows levels, turbidity etc Select the most viable perennial source closest to the community.				
2.	**RAW WATER QUALITY ANALYSIS** Carry out a Chemical/Bacteriological quality analysis on Raw water				
3.	**SOURCE WATER/INTAKE WORKS** (a)Expansion of existing water pond or spring source by excavation with a bulldozer and construction of intake works on the pond				
	(b). (Pump 1) Supply and install a 3HO petrol Centrifugal pump with Head of 20m and maximum output of27m^3/hr (6,000gh)	LUMP	SUM		
4.	**AERATION/COAGULATION/SEDIMENTATION TANK (CLARIFIER UNIT)** (a) Construct a 4,500gals, (20.0m^3) capacity 12' (3.6m) x 5 (1.5m) open tank made from 225mm concrete sloped floor and dislodging drain gutter				
5.	Supply and install a 3HP petrol centrifugal booster pump to boost clarified water through pressure filters (same specifications as above)				
6.	**PRESSURE FILTERS** (a) De-acidizing pressure tank: Supply and install a 450mm diameter x 1500mm high pressure tank constructed from mild steel plate of 6mm thickness complete with all valve and fittings, charged with sand and calcite for PH correction. (b) Taste/odour pressure tank: Supply and a 450mm- diameter by 1500mm high pressure tank Ditto-4 (a) but tank charged with filter sand and carbon granules for removal of taste, odour and colour.				
7.	**CLEAR WATER TANK** (a) Construct a 4,500 gals (20.0m^3) capacity 12' (3.6m) x 12'(3.6m) by 5' (1.5) tank made from 225mm concrete filled Block wall with reinforced concrete slab roof and concrete floor.				
8.	Plumbing, Fittings and Provision of service taps.				
9.	Transportation and Delivery of all materials installation and commissioning of plant.				
10.	**CLEAR WATER QUALITY ANALYSIS** Carry out a Chemical/Bacteriological quality analysis on Treated water.				
	TOTAL				

9.0 Conclusion

It is established in this paper that the rural water supply challenge in Nigeria is more of a **"Quality Issue"** rather than a **"Quantity Issue"** since Nigeria is blessed with a lot of surface water resources through a system of drainage network. Raw water quality of rural water is not as bad as those of the urban waters which are more highly polluted due to industrialization. In general, the application of the pressure filter system in meeting rural drinking water demand of any sate or community, involves:

i). A survey and identification of the various communities' existing surface water sources (e.g. Springs, Perennial rivers, Waterfalls, Lakes, Water table effluent ponds etc) [8].

ii). Improvement of the source intake by expanding it to an infiltration gallery or diversion channel. Construction of a Detention/Clarifier unit for addition of chemicals (if necessary) and pumping the clarified water through the filtration system, it then becomes potable and completely free of guinea-worm and other forms of schist infestation. This then becomes a simple, practical, cost-effective means of combating the guinea-worm scourge nationwide.

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