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Strategies and techniques of providing adequate and affordable potable water in rural areas of Nigeria

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Water is next to air in importance. The World Bank declared water as an economic good while endorsing the international demand for water supply. Human health depends on having access to safe, adequate and reliable water supply. In Africa, and of course in Nigeria, one half of the entire continent's people (particularly in rural areas/communities), suffer from one or more of the six main diseases associated with poor or polluted water. Statistics show that Africa has the highest occurrence of cholera and typhoid epidemics as well as child diarrhea. Of the 46 countries in which schistosomiasis are endemic, 40 are in Africa, of the 19 countries reporting guinea worm, 16 are in Africa. In September 2000, 147 heads of state and governments, and 189 nations in total, committed themselves to the Millennium Development Goals (MDGs). One of the targets defined for achieving the MDGs is to "halve by 2015, the proportion of people without sustainable access to safe drinking water and basic sanitation". This paper constitutes a source of information for water and sanitation coverage estimates in southwest geo-political zone of Nigeria. It provides information of the current status of water supply and sanitation in the zone. The paper attempts to look into the appropriateness of the use of the technology of integrated mini water scheme and infiltration gallery as a means of providing safe and adequate domestic water to rural community people to serve as the best preventive medicine against the prevalent water diseases.

Key words: Strategies, affordable, adequate, potable, water.

INTRODUCTION

Water is a ubiquitous chemical substance that is composed of hydrogen and oxygen and is vital for all known forms of life. In typical usage, water refers only to its liquid form or state, but the substance also has a solid state, ice, and a gaseous state, water vapor or steam. About 71% of the Earth's surface is covered by water. On Earth, it is found mostly in oceans and other large water bodies, with 1.6% of water below ground in aquifers and 0.001% in the air as vapor, clouds (formed of solid and liquid water particles suspended in air), and precipitation. Oceans hold 97% of surface water, glaciers and polar ice caps 2.4%, and other land surface water such as rivers, lakes and ponds 0.6%. A very small amount of the Earth's water is contained within biological bodies and manufactured products.

The impact of water use on our ecosystems should be an intricate issue of special concern in every area of the world as water is the one resource we cannot live without. Water is our most precious resource. Yet it is currently under attack by our waste, pollution, privatization, and the exacerbation of climate change. We must be aware of this and work to preserve and conserve water for future generations. This will be our legacy to our children (Harlander and Labuza, 2006).

It is good to finally see life cycle assessments being done for water use. More water is wasted (and polluted) in industry, yet they are not accountable for the water they use. And even though these assessments are not

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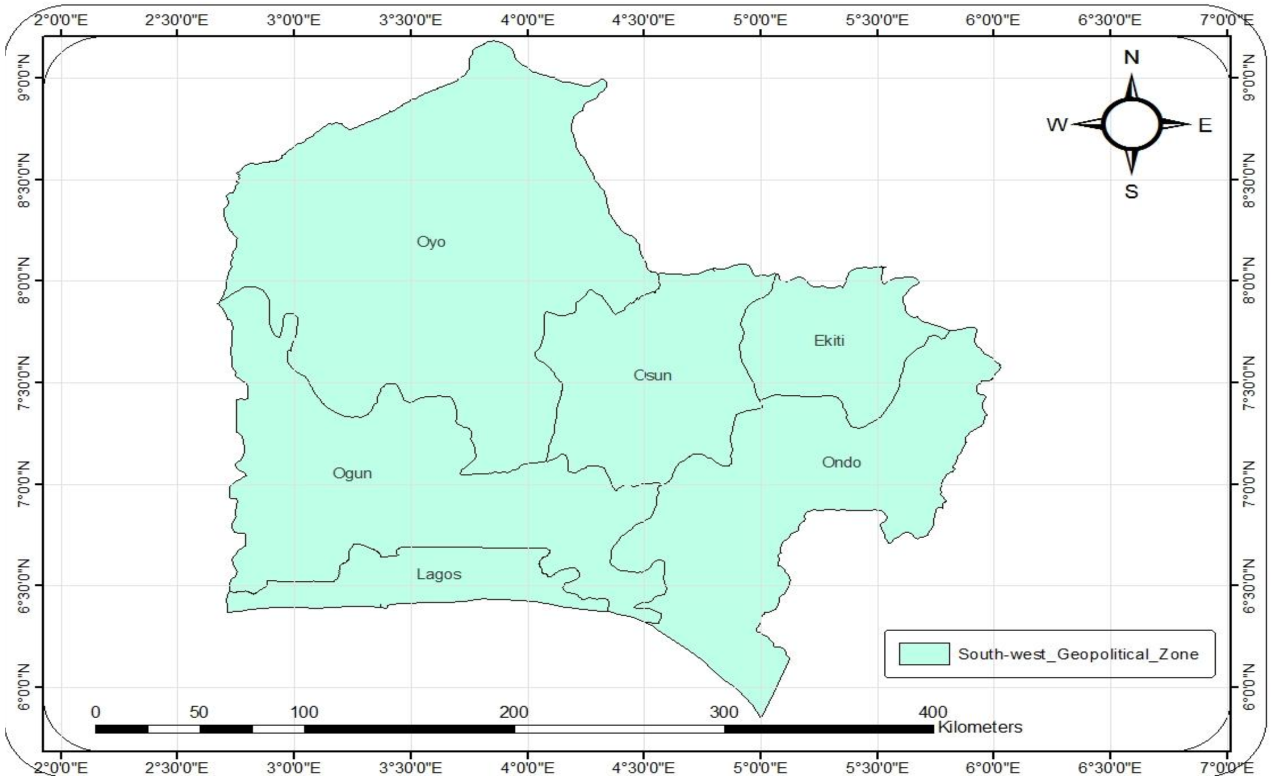

Figure 1. South-Western Nigeria.

based on changing factors over time, they at least give a good idea of what is being used, wasted, and how best to conserve water in different regions of the world experiencing different effects regarding that usage due to population, population growth, deforestation, agriculture, and now chiefly, climate change which is precipitating drought and melting glaciers more rapidly which absolutely effects the life cycle of water and all that depend on it (Osho and Dashell, 1997).

Africa is endowed with abundant water resources although its distribution and availability for use varies widely, with quite a number of countries facing water shortage and water stress. Regional and national water figures often conceal the dramatic effects of local water scarcity, limited or polluted supplies and inadequate distribution systems. Access to fresh water has been identified repeatedly as a key condition for development. National water policies and conservation efforts often tend to focus on the supply-side for domestic and agricultural use, and less commonly on industrial needs. Under these circumstances the uncontrolled use of a limited resource by water intensive industries takes on a special significance (UNEP, 2006). Potable water supply in our rural is achievable when we take all the necessary steps to achieving this, Adesogan (2008) stated that our world can be a world of plenty if we wish to make it so. In the past, many attempts have been made to solve the problem of water supply. These include the use of stream waters; construction of reservoirs and digging of shallow wells. These methods are not full proof as there are still records of potable water shortages even with these in place. The construction of reservoirs makes water to be susceptible to odour because the water in the reservoir may not be adequately aerated. Shallow wells, if too close to the septic tank can be polluted. These problems arising from poor water supply are crucial in the development of any community and efforts must be made to minimize or where possible eliminate them. An understanding of the strategies and techniques of providing potable water in our rural areas is necessary to be able to achieve this and therefore, there is need for this research. There is therefore the need to look into the appropriateness of the use of the technology of integrated mini water scheme and infiltration gallery as a means of providing safe and adequate domestic water to rural community people to serve as the best preventive medicine against the prevalent water diseases.

Study area

This study was carried out in Southwestern Nigeria comprising Oyo, Ogun, Lagos, Ekiti, Ondo and Osun states. The region has a bi-modal wind pattern with peaks occurring in April and August associated with rainstorm causing pollutions to water sources (Figure 1).

Table 1. Summary of water supply situation in Southwest Nigeria.

State	% Access to improved water supply			% Water supply coverage		
	Urban	Small towns	Rural	Urban	Small towns	Rural
Ekiti	56	68	57	29	33	27
Lagos	87	83	73	24	21	21
Ogun	84	66	55	49	36	27
Ondo	67	60	60	18	16	16
Osun	71	62	44	23	25	17
Oyo	72	59	54	27	22	21

Source: Survey (2009).

METHODOLOGY

Survey of water supply in South-Western Nigeria

The zone has six States out of which Ekiti State was selected as the pilot state for the research. The study approach involves the use of survey forms (questionnaire) designed the MIS consultant appointed by the Client. The forms are: Form 01 (Water Supply Facility Survey): To capture the location, attributes, and operational status of water supply facilities; Form 02 (Water Supply Agency Operational Survey): To collect data on the profile of water agencies in the state, in terms of production assets, capacity utilization, manpower; and financial sustainability; Form 03 (Sanitation Facility Survey): To capture the location, types and conditions of sanitation facilities; Form 04 (Water Related Diseases Survey): To collect data on reported cases of water related diseases from health institutions; Form 05 (Household Survey): To capture data on the proportion of households that have access to safe drinking water and sanitation facilities and prevalence of water related diseases in each community; Form 06: (Summary form for the Local Government Area).

Primary information was obtained through household survey carried out by recruited and well-trained enumerators. The survey was carried out in every ward in each of the six States of the geo-political zone. Within each ward, at least 24 houses were selected. Where the ward is a multi-community ward, the selected houses were shared among two randomly selected communities in the ward. However, for multi-ward communities, that is, communities with more than one ward within them, the selected houses were systematically spread among two randomly selected streets or quarters in the community. Facilities survey and determination of their coordinates were carried out by members of the project team with the aid of GPS. Secondary information on water supply and sanitation in the zone were obtained from the LGAs, State Water Boards/Corporations, State Ministries/Agencies of Environment, Ministries of Rural Development, Benin-Owena and Ogun-Oshun River Basin Development Authorities, water supply schemes, other sanitation offices and health institutions across the geo-political zone. Preliminary results of the study were discussed with stakeholders in each State de-briefing workshop where genuine concerns were addressed. State draft reports were circulated to respective State officials and a Zonal workshop organized to review the draft reports.

RESULTS AND DISCUSSION

Results of the water supply situation in the different settlement classes of the zone are summarized in the Table 1. With values mostly between 16 and 36%, water supply coverage is poor in the zone. The 49% value for urban Ogun State notwithstanding! However, access to improved water supply is much better all across the geo-political zone. Variations of these parameters within each Local Government Area are presented in individual State reports and in the zonal report. The results form the basis of calculating MDG targets as regards water supply by the year 2015. To meet this target, there is the need to substantially increase the water supply coverage from its present state all across the zone. In terms of sanitation, Table 2 presents a summary of percent access to sanitation facilities in the geo-political zone. Apart from Lagos, and to a lesser extent Ogun State, access to sanitation facilities is very poor in the zone. This result is further reinforced by the very little sanitation facilities mapped out during the survey as compared to water supply facilities. To accomplish the MDG target, there is a need to increase the number of sanitation facilities and pay more attention to people’s access to the facilities. There are basically five categories of water supply promoters in the zone, with the State Governments being responsible for 100% of the surface water development. Even those developed by the Federal government are eventually handed over to their respective State governments. There are also the same five providers of sanitation facilities in the zone.

Disease survey

In the survey of more than 1,400 health institutions within the zone, malaria was found to be the most dominant water-related disease in each State of the zone. Typhoid, dysentery and diarrhea were found to be widely reported throughout the zone.

Strategies and techniques

Water supply schemes

Single-large and infective water schemes: In urban centres of developing countries with particular reference to Nigeria, Community water supply systems are

Table 2. Summary of access to sanitation facilities in Southwest Nigeria.

State	Total population	% Access to improved sanitation facilities
Ekiti	2,384,212	46.1
Lagos	9,013,534	84.8
Ogun	3,728,098	65.2
Ondo	3,441,024	36.7
Osun	3,423,535	36.5
Oyo	2,297,874	32.5

Source: Survey (2009).

fashioned after those that obtain in the industrialized countries with little or no adaptation. For example, Ado with a population of over 3.0 million is served from only a waterwork from Egbe with 180 million litres/day capacity. The water works combines Convectional treatment plant with mechanical pressure Filters in an arrangement that is very confusing resulting in frequent operational breakdowns. A disadvantage of this is that breakdown of the scheme will lay off all towns and villages supplied simultaneously. The distribution network is very scanty covering only about one-fifth of the entire city with complete neglect of the newly developed and economically viable areas of Omisanjana, Dallimore, Ajilosun, Opopogbooro etc. Only four reticulation reservoirs served the whole city with only three booster stations. Obviously, this cannot be an efficient system.

This same problem is likened to the old adage that “the strength of the chain is in the weakest link” in appraising the nature of the Ado water supply schemes. Ikere, Ise, Iju-Itaogbolu and many other villages are supplied from Ikere waterworks. Aramoko has only one waterworks, Irele, Itapaji, Ire, Oye, Agbado and Omuo were expected to be supplied from Ikole waterworks about 12 km from Irele. It is very clear and logical from the descriptions of some of the water scheme that acute water shortage has to be a citizen of our country. How do we “deport” this unwanted citizen?

Mini-water schemes

A study of 50 km radius of the city of Ado will reveal sources that could be harnessed separately for min-water schemes and which will meet the city’s ultimate demand if integrated together. Adesogan (2000) in projecting the potentials of mini-water schemes identified over 60 streams in Ado land most of which take their sources from springs. Adeniran (1997) has proposed the use of 6 mini-water schemes as supplements to the two gigantic water schemes in Ibadan. These include Olodo, Omi-Adio, Odo Ona Elewe, Ogunpa behind St. Patrick’s Grammar School at Idi-Ape Basorun, Tabielede at Ajibode and Sango/Oba at University of Ibadan. It is interesting to note that this report which was submitted at the end of Training course in the United States was never considered by the Water Corporation. It is doubtful if the report was ever brought to the notice of Government. It is however, gladdening that the same report was used by the University of Ibadan in developing the 6.0 millions litres/day mini-water scheme for the University. This scheme which serves a population of only 25,000 has made the University an oasis in the desert of Ibadan city. The U.I. scheme is maintained and operated by a total staff thus keeping overhead cost to the barest minimum. The scheme is also designed in modules such that any of the three modules can be operated without reference to others. This parallel arrangement makes water to be available at all times.

The importance of mini-water scheme can further be appreciated if an integrated water scheme is considered as is done in New York City. The entire city of New York with 5 Districts was discovered with 72 waterworks as at 1987. The largest of this waterworks only produced 20 Million litres/day. The water schemes are integrated in what was referred to as the “Pentagon Support Integration”.

Each of the mini-water schemes is completely independent serving only a population of between 10,000 and 30,000. Each water scheme is under instruction to produce about 25% more than the water demand of the area that it serves. This is to take care of emergency fire hazard and to render immediate “support” to a sister water scheme that might be having a “breakdown” problem. This way all areas are covered effectively on a 24 h basis either from “internal supply” or from “support supply” obtained from all nearby pentagons. The staff kept by each water scheme is scanty. Of course, the revenue collection is not the business of the water scheme; this is carried out by private entrepreneurs. These business organizations only receive a the bill from water supply management authority on the basis of the quantity of water supplied to their area. These organizations pay immediately and arrange to collect the bills from consumers in their area. Water is thus a business in its own case and not a social service. Adequate records are kept of industrial developments, population changes etc. Any new development or expansion is expected to be self financing.

Private sector partnership

At present, Government, through the State water agencies seems to be singularly saddled with the responsibility of providing public water supply to the people. Water is often made a political issue. Such central institutions alone are not generally able to support large numbers of water supply schemes with the technical, human and financial resources required for successful long-term operation and maintenance.

Funds

Data collection, designing and construction of water supply schemes are very capital intensive, so also its operation and maintenance costs are very high. The high cost makes many governments to shy away from embarking on provision of water supply. The National Policy on Water Supply and Sanitation stated that 404.522 billion would be needed to address the absolute demand gap and increase by about 25 billion per year to increase the existing capacity of waterworks and construct new ones.

Capital cost

Due to high capital costs and lacking of securing of loans, there are many completely designed schemes gathering dusts in our offices and waiting to be constructed. For example, Ijan, \Aisegba, Ode and other towns and villages' water supply scheme was completely designed in 1991 but could be constructed due to lack of fund. As a result, of time-lag, the design is now obsolete and had to be re-awarded to another consultant who promised to secure loan for the construction of the scheme. This is yet to be actualized.

Others are mini-water supply schemes for eight local government headquarters in Ekiti State. The National Water Supply and Sanitation policy suggested that the capital cost of project be shared amongst the Federal, State and Local Governments and the community in the percentages shown in Table 3.

The National Policy also advocated cost distribution for operation and maintenance as shown in Table 4.

Also "business as usual" for provision of water supply must stop and "business unusual" must be adopted if all citizens of this Nation must have access to potable water by involving private sector participation in water supply. There are various options of Private Sector Participation as service, management, lease, Build-Operate and Transfer (BOT) and concession contracts which are available and being used by many countries including developing countries in the world. However, there must be a very strong political leadership before some of the options could be used.

Involvement of entreprenuers

The general discussion in the Nigerian water industry today is commercialization. Lending agents continue to emphasize that the water agencies become economically sustainable. This is a laudable and welcome development. However, from experience elsewhere in the world it is established that this thrust towards commercialization along will not be sufficient to change the culture and improve the efficiency without the autonomy of the water agencies. Waller (1998) has suggested that without the commercial freedom to employ staff, but chemicals, maintain plant and operate as a business outfits the SWA's will remain hindered however efficient they manage to be.

The Government may not want to release SWA's from their control except it is to the private entrepreneurs. However, the World Bank experience indicates that management contracts suffer from a similar fate to commercial operation without autonomy. The output of an organization cannot be improved without the ability of the management to make its own decisions. Hence, the involvement of private sector is critical step in achieving independence and hence a proper commercial capability.

It is obvious, from performance indices, that most of the Water Agencies in Nigeria and the developing world are poorly established in terms of physical and human resources that development by Government and technical assistance are the only option left for them. However, if strong management is introduced, many of the agencies can ensure that operating expenditure is at least brought into balance with revenue collection. This will often necessitate the increasing of tariffs in accordance with a well determined unit cost of production. The options for involving the private sector in the Nigerian water supply industries can be addressed by focusing on the development of assets information, encouragement of the private sector, regulation and reduction of running costs.

Health engineering with minimal resources

One of the themes running through this paper will be the intension of a growing understanding that aid or the direct giving of help is not development, and tends to be detrimental in the long term. In countries of Africa, this includes giving by Central Government as well as giving by external agencies. But there is also the realization of the need for pump-priming by outsiders, the urgent need for a catalyst to release the inherent abilities of the people. This can be seen most clearly in the requirement which gradually became clear of the need to ``invest'' on occasion in expensive structures which apparently served no particular purpose in improving health. For example, permanent materials Primary Health Care Clinic might appear an unnecessary luxury when compared to an improved mud, wattle and thatch building with a 20 to 1

Table 3. Water supply scheme.

Agency	Rural (%)	Small town (%)	Urban town (%)
Federal Government	50	50	30
State Government	25	30	50
Local Government	20	25	10
Community	5	5	10

Source: Federal Ministry of Water Resources.

Table 4. Water supply scheme.

Agency	Rural (%)	Small town (%)	Urban town (%)
Federal Government	-	-	-
State Government	10	-	100
Local Government	20	-	-
Community	70	100	-

Source: Federal Ministry of Water Resources (2008).

cost difference. However, it could serve a vital purpose in proving to the people that development was coming and would benefit hem. The other major lesson learnt was that although it is so easy to look down on people in such a situation, considering them underdeveloped with little initiative and little willingness to help, they were survivors. They were the ones who had managed to live through a long time in a hostile environment. They were therefore canny and wise and manipulative and in a very reasonable way were out to get the best for themselves, their people and their District. Not surprisingly this meant they wanted to see the largest amount of money invested in their District in the shortest possible time. They wanted structures and hardware and goods and medicine and were not enthusiastic to hear about community participation and the need to use their own resources.

Community involvement in water supply

Now it became possible to discuss alternative forms of improvement to existing water sources, particularly in areas where the people were widely scattered. The Community Health Workers responded enthusiastically to the opportunity to carry out a survey of water resources in their area and, with the people, to recommend ways of improvement. In the areas where unlined hand-dug wells were used already, concrete culvert rings being used in feeder road upgrading could be given to seal off the well from surface water intrusions. In other areas where there is stream a couple of bags of cement could allow a small masonry dam to be built on a stream to increase the storage of water in the sand during the dry season. Such sand reservoirs gave natural filtration, limited evaporation, prevented mosquito breeding on stagnant pools and by reducing the frogs' habitat reduced the number of snakes.

In an area which had proved fruitless for drilling because of the un-weathered fresh rock, part of an outcrop could serve as a natural reservoir which could be cleaned out and enlarged by a small masonry wall. This rock catchment would enable them to use the results of the rains for their water uses. Community involvement does not always have instant result of course. News of failure in any development project appeared to spread very quickly through a community. News of success was less obvious but people were watching and gauging what was going on and when an idea worked it picked up momentum and schemes appeared to multiply exponentially.

Artificial recharge and recovery method

There are natural ground water replenishment or recharge methods. It was noticed that this increases the volume of water in the soil, and raised the ground water level. The phenomenon was particularly noticed in the arid and shore or coastal areas. The subsequent rise in: (1) population; (2) surface water pollution, and (3) water consumption.

Definition of artifical recharge

Artificial ground water recharge could be defined as planned activities of man whereby surface (streams, rivers, lakes) waters are made to percolate and infiltrate the ground at rates and in quantities many times in excess of natural recharge. By judicious design of recharge and recovery cycle, corresponding increase in the amount of ground water abstracted is possible with impeccable bacteriological quality.

Methods of artifical recharge (AR)

Ground water reserves in the aquifer can be increased in two major ways.

Natural / artificial method: Which is generally referred to as indirect method? In this case, increased replenishment is obtained by locating the means of ground water abstraction (infiltration gallery, large or small diameter well), close to any surface water (stream, river or lake with porous or pervious banks within a well accompanying abstraction (by pumping) will result in increased in flow of water from both the surface water and the aquifer sources through the pervious soil. This method is otherwise called induced recharge.

Direct method: This is the method by which water from a distant (or near) surface source (stream, river, lake, pre-treated sewage water, storm drainage) is transported or conveyed to areas or point where it is spread over the surface of previous soil basins, ponds, ditches or furrows and by pits, shafts, channels or by mere flooding in less pervious soil.

Induced or indirect artificial recharge: Criteria of design

As described previously, induced AR is the situation whereby water is drafted into the soil by locating as infiltration gallery or a (small or large diameter) well at small but carefully designed distance parallel to a surface water source (stream, river or lake).

At beginning of the water recovery to the rural area, the water pumped out $q_o = q_n$. This is the case when the ground water table is higher than the water level in the surface source nearby (where q_n is the natural underground water level in the surface rainfall P). As the water demand increases, pumping rate increase, the ground water level will fall below the surface water level. At this time recovered water q_o could be expressed as follows:

$$q_o = \ + q_n$$

Where q_s is the water induced by pumping from the surface source through the soil into the gallery or well at distance, L form the source. This is the artificial groundwater supplied by downward percolation of the river water which infiltrates the pervious soil into the gallery or well or a battery of them.

Use of well

Induced ground water recharge with gallery is not only possible when the ground water is not at a great distance single well bear a surface may suffice but when the demand is large a line of wells parallel to the streamed is used.

Single well for small demand

When a single well is used, the only design factor is the distance L between the well and the shore line. The drawdown S_o is small and it is localized. Thus, it des not form a design limiting factor. Also, the entry rate V_e of the surface water into the aquifer is not a boundary condition as the aquifer is deep down. Thus detention time T for the flow of surface water to well is the only design requirement, the distance L must satisfy. And minimum required distance L of the well to the shore line. Therefore with the notion, the elevation h of the ground water is expressed as (using Darcy and continuity equations as applied to unconfined/and semi confined aquifer).

Battery of parallel wells for large capacity

When is needed to supply large amount of a cluster of villages or rural communities, urban segmented communities, or about 100,000 to 200,000 people, whose water demand is in the order of 0.23 m^3 /s (about 20,000 m^3/day) and above, induced recharge and recovery by battery of wells is the right solution. All the wells must be located at a distance “L” parallel to the shore line or streambed.

Design assumptions

The wells are each at a distance L from the shoreline/streambed. The distance of the wells from each other is a small distance, “b’’ compared with their distance L from the streambed. In the above two conditions, the flow pattern is assumed equal to that of a gallery with capacity. These three conditions simplify the design of this artificial induced recharge scheme to be exactly the same as for a gallery. A constant value of coefficient of transmissibility KH is assumed and that the river fully penetrates the aquifer thickness.

Conclusion

It is therefore not out of reason for water resources and environmentalengineerstore-access theabovesubmission (a mere reminder of what exists), then enlist the artificial recharge and recovery (AR & R) method in the list of water supply options to rural or small communities.

Mini water supply option based on small communities in all the local government area should replace the ineffective and inadequate gigantic option that is the vogue now. Decentralization of water supply scheme with monitoring, administrative, financial and technical authority shared between the community users (stakeholders), local and state governments. This will give and ensure efficient method for effective production of adequate hygienically reliable water that can ensure and give preventive medicine for the local/rural dwellers against water-borne disease.

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