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Sustainable Development for Storage of Surface Water Due to Sinking of Under Ground Water Level: Public Private Partnership

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Abstract

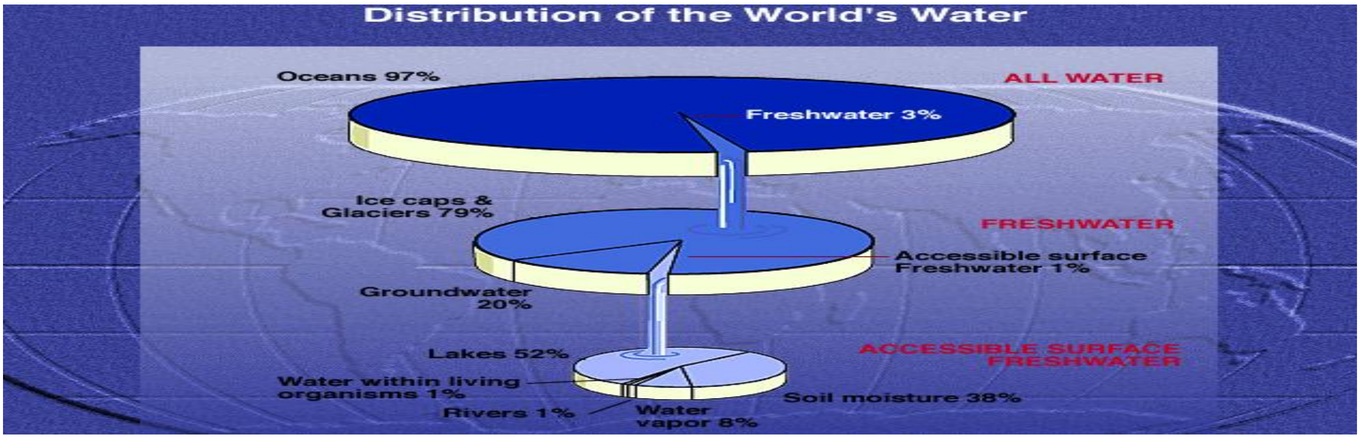
Degradation of the grazing lands in the Sahel has led to increasing concern about the necessity for maintaining the right balance between the available water supplies, available vegetation for browse and grazing, and the intensity of use by livestock. The flat-batter dam, or spread-bank dam, is another water harvesting method, from the area of Rainfall is about 400 mm but most falls at low intensities. The terrain is flat or gently sloping sandy soils overlying clay and, together with the low intensity rainfall, this makes roadbed catchments unsuitable. The coefficient of run-off is not always as high as might be expected from bare rock surface, and can go down to less than 50 percent due to losses from evaporation, surface depression storage, and losses through fissures and cracks. Limestones are usually weathered and fissured, and may yield as little as 25 percent, while a steep solid granite may yield 80 or 90 percent. The yield can sometimes be increased by sealing the fissures with cement or bitumen. An alternative way of reducing infiltration is to physically block soil pores on the surface. This can be done by adding bentonite, a very fine colloidal clay used for sealing the floor of leaking reservoirs, or mixing cement into the surface soil to form a soil-cement stable layer. The harvesting and use of water by storing it in dams, tanks, and other constructed containers is too big a subject for detailed treatment with engineering tools .The surface to the ground water level with respect to qutub is presently 405 ft as on day and it goes on decreasing day to day is subjected to 800 ft in 2030 is measure concern at the present decades .The author predict the storage of the water and generate the hydro power by connecting the river to river and enhancing the government business is measure concern and compared to other Asian nation like China covering @ 75% of the electricity produces through the hydro power

Key words: *Sinking, harvesting, Degradation , grazing, Degradation , grazing*

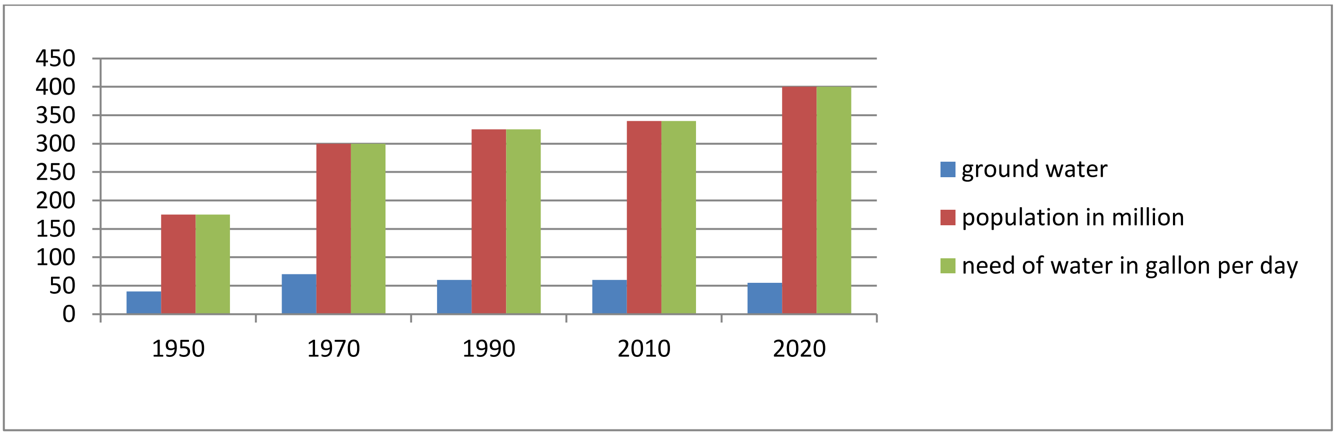
1.0 Introduction

The Harvesting Method is utilized for 1% water within living organism and the world is required for distribution of water of ocean 97 % and 3% as fresh Water. The 3% of the fresh water on which 79% of water with glacier and ice caps and ground water of 20% as well as 1 % of accessible fresh water. The 1% of fresh accessible fresh water are accumulated 52 % in lakes and 1 % water within the living organism, 1% of the water exists with the rivers and 8% of the water are transferred in the forms of vapour and 38 % of the water retains as moisture in the soil. The sinking of water is measure concern of the present era as such the sinking of water with respect of Qutub is approximately 504 ft. The harvesting of water is through storage of water as well as recharging the existing basin. But a new innovation and recent techniques is required is presented in this technical paper. These water may be used for domestic, irrigation water and thermal power water requirement and industrial purposes.

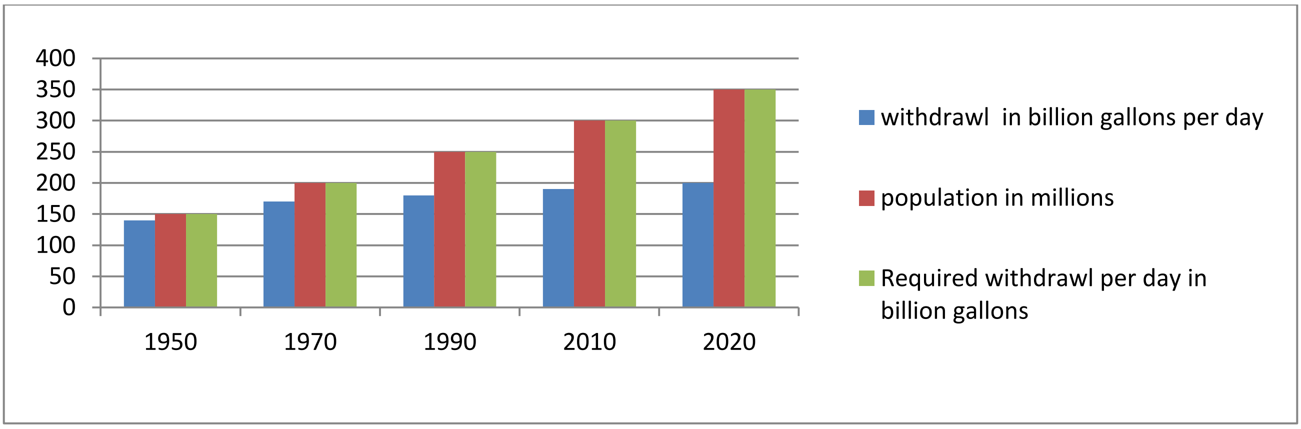
Distribution of the world's water



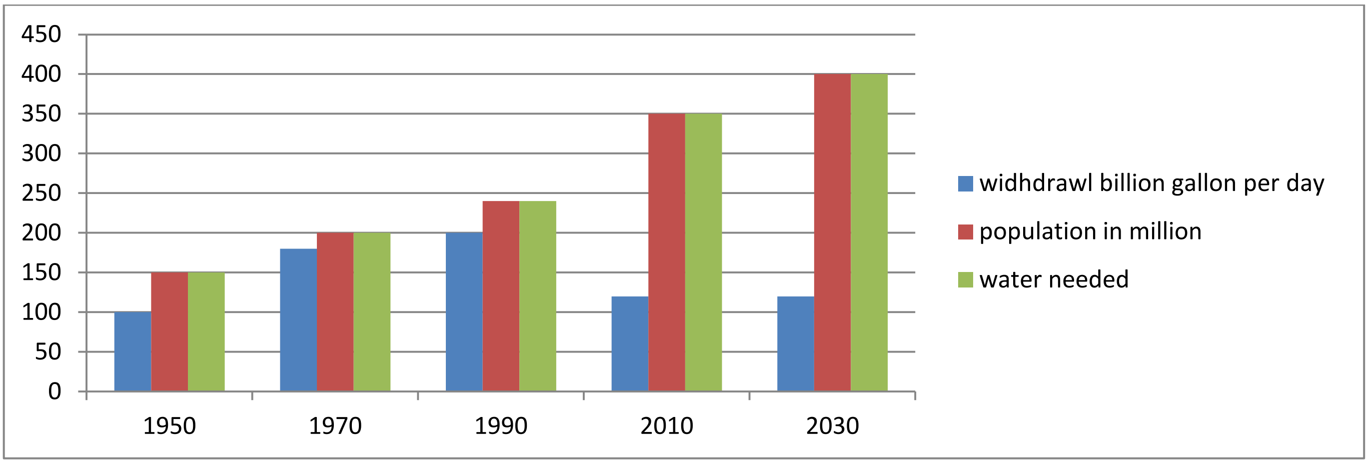
1.1 Ground water and surface trends of population growth vs. fresh water by 1950-2016; the water is expected as on 2020 become as 190 millions of population would get fresh water 280 billion gallon of water per day. Comparing the status of underground water and depletion is too high is the measure concern of the technical papers.



With drawls of water in billion gallons per day for the irrigation purpose is becoming very high i.e. 350 billion gallons per day. The trend of the water requirement as on 2020 become 350 billion per day is measure concern, due to rate of sinking and depletion water over all worlds.



1.2 The forecasted and assessment of the water requirement form resources in thermal as on 2020 is 400 billions gallons per day against the population of 350 millions. The basic need water storage day to day increasing and the availability of the water from the resources goes on decreasing from the last decades all over the world.

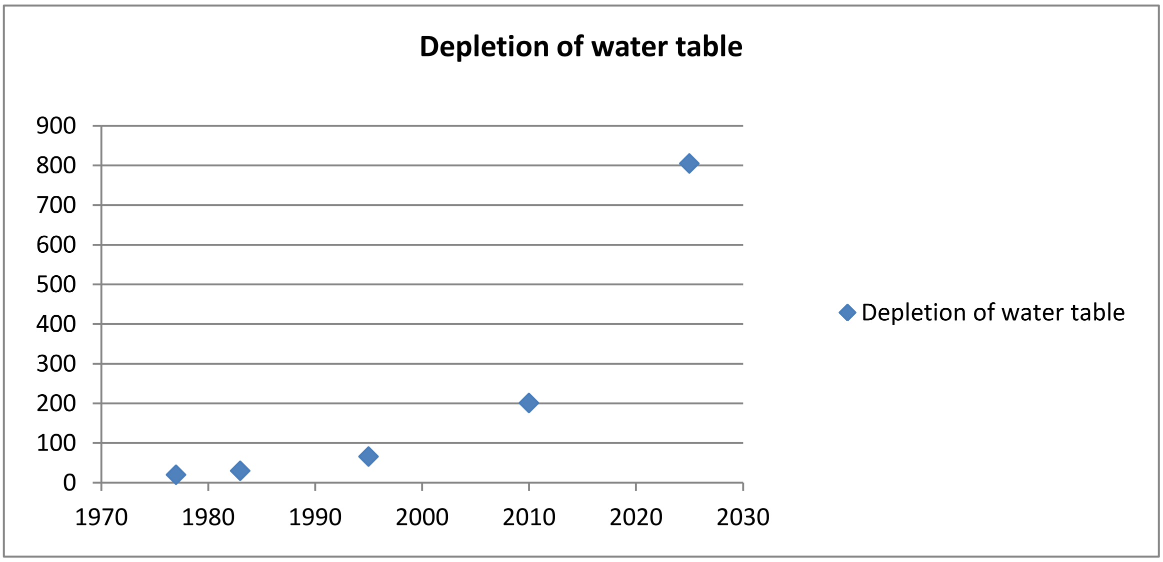


1.3 Measure concern of Stock of water below the ground in cisterns, lined ponds, above the ground in tank structure, larger quantities for irrigation, Hydro power and thermal usually in Dam, ponds, reservoirs. The concern is the catchment whether the catchment is natural or treated. Factors to be considered in the design are: the amount of required water, which can be calculated from estimates of the numbers of people or stock and their daily requirements, or from the area and requirement of crop; rainfall, its frequency probability, and intensity, which combined with surface conditions will determine the run-off, and hence whether some change is required to increase the run-off; losses of the stored water through evaporation, seepage, or' leakage

The Degradation of the grazing lands in the Sahel has led to increasing concern about the necessity for maintaining the right balance between the available water supplies, available vegetation for browse and grazing, and the intensity of use by livestock.

The world technocrat view over the plantation and focusing how the plantation over the catchment decreasing the retaining of the water over the catchment and reducing the runoff. Reducing the plantation over the area will increase@ 20 % of the water storage capacity over the catchment, it due to fact the infiterarion rate of plantation decreases @ 40%, world technocrat views and experimental approach.

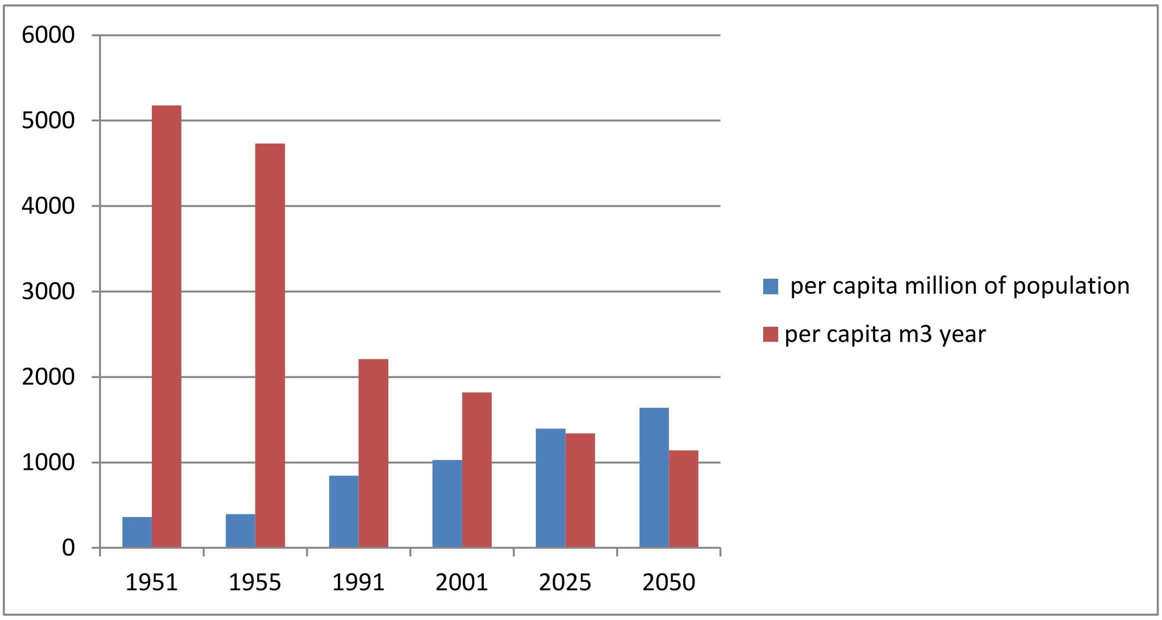
2.0 Sinking of underground water level during decades:



The rate of depletion of water table during the last three decades were analyzed and based on the depletion rate of the water table it is further analyzed to get a water table depletion at the end of 2025 become 805 ft is with reference to the Qutub Minar i.e. 237 ft from the top of the qutub to the ground level is added while considering the water table below the ground level.

Now the depletion rate present era showed that the value become 405 ft is the measure concern of the storage of surface water for drinking purpose, irrigation, thermal and Hydro power etc. The depletion rate is shown through a graphical representation in which the trend of the graph reaching from the 20 ft to 900 ft

2.1 Availability of water per capita



The presentation of water availability during the next decades showed that the availability trends of waterfalls suddenly during the decades 2050. Author prediction in this regards is the basic reason of decreasing trends is due to depletion of the ground water table and their remedies are highlighted in the world water day 2016.

3.0 Remedies: Treatment of catchments; Natural Catchments and Minor Changes, Major and Minor treatment work

A_ Methodology for the major treatment work:

3.1 i) Collection of disturbed and undisturbed sample by means of site exploration ;

Method

The cohesionless soil generally available at the river beds and it is required to analyze the properties of the respective soil by means of site exploration. Rotary drilling method of boring is useful in case of sands and silts. Here, the bore holes are advanced in depth by rotary percussion method which is similar to wash boring technique. A heavy string of the drill rod is used for choking action. The broken rock or soil fragments are removed by circulating water or drilling mud pumped through the drill rods and bit up through the bore hole from which it is collected in a settling tank for recirculation. If the depth is small and the soil stable, water alone can be used. However, drilling fluids are useful as they serve to stabilize the bore hole.

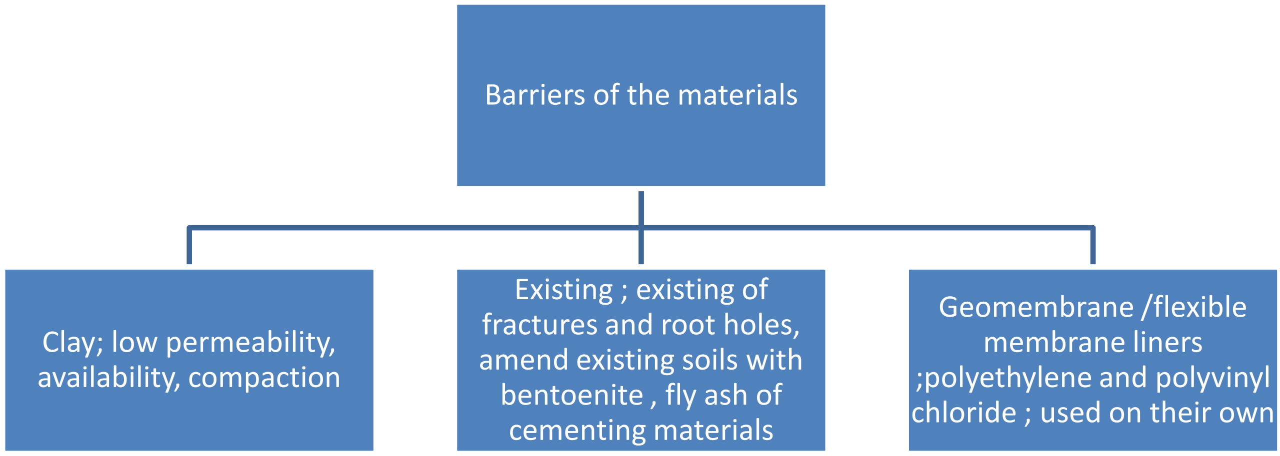
Drilling mud is slurry of bentonite in water. The drilling fluid causes stabilizing effect to the bore hole partly due to higher specific gravity as compared with water and partly due to formation of mud cake on the sides of the hole. As the stabilizing effect is imparted by these drilling fluids no casing is required if drilling fluid is used. This method is suitable for boring holes of diameter 10cm, or more preferably 15 to20cm in most of the rocks. It is uneconomical for holes less than 10cm diameter. The depth of various strata can be detected by inspection of cuttings.

The strata available are almost cohesive, soft to stiff cohesive soils as well as ground water table in side bank and embankment while construction of Dam and diversion tunnel. The disturbed sample can be opened from the Augor method of sampling and is better than the wash boring system. But the method is unsuitable for fully saturated cohesion less soils.

3.2 Percussion drilling

It can be used in most of the soils and rocks and can drill any materials. The sample obtained are undisturbed and hence good quality of undisturbed sample cannot be obtained. The advancement of hole is done by alternatively lifting and dropping a heavy drilling bit which is attached to the lower end of the drilling bit which is attached to the cable. Addition of sand increases the cutting action of the drilling bit in clays. Whereas, when coarse cohesion less soil is encountered, clay might have to be added to increase the carrying capacity of slurry. After the carrying capacity of the soil is reached, churn bit is removed and the slurry is removed using bailers and sand pumps. Change in soil character is identified by the composition of the outgoing slurry. The stroke of bit varies according to the ground condition. Generally, it is 45-100cm in depth with rate of 35-60 drops/min. It is not economical for hole of diameter less than 10cm. *Collected samples will go for the test and modeling to give a right approach of spreading Bontoenite including other slurry for retaining the water in the storage river based dam to convert the water into the hydro power generation and other facility .*

3.3 Barriers of the materials



The top layer existing with filter fabrics and below the filter fabrics leach mound is connected with the drainage layers. Below the above layers clay liners are provided. Initial stages are to allow the soils with the bentonite, fly ash or cementing materials to retain the water on the top surface and increasing the quantity of runoff.

3.4 The basic need to cover the river basin before commencement of Hydro power generation at least the area covered during the peak duration of the water storage, so that the sinking effect during low discharge rate and storage of water should not affect the Hydro power generation and capacity of storage for thermal as well as irrigation or drinking purpose. The approach betonite is to use water-repellant chemicals and reducing infiltration is to physically block soil pores on the surface. This can be done by adding bentonite. The current capacity of ca- bentonite alone become 960 A-hrs per Kg with initial and final potential as 1.6 and 1.5 respectively. However backfill Na2 SO3 is added 970 A-hr /Kg with initial and final potential as 1.585 and 1.584 respectively. If backfill s-66-40% , Na2 So3 is added with current capacity of 1180 +350 and 540 +160 with potential initial and final as 1.65 and 1.557 . A very fine colloidal clay used for sealing the floor of leaking reservoirs, or mixing cement into the surface soil to form a soil-cement stable layer. The deflocculated soil so providing fine particles to seal the surface in the same way as bentonite.

The method of mixing ingredient from preventing the surface water into the ground water table are generally 4 to 7 % bentonite slurry out of a water quantity of 68 to 88 % . However cement without replacement become 8-25% , when blast furnace are also added become 1-3% and when fly ash is also added , the quantity of the fly ash are added as 2-7 % .

If blast furnace slag are used, the % of the blast slag are taken as 7-22 % , however fly ash are added 6-18%. The above mix gradient is subjected with the catchment of river basin to avoid the increasing rate of infiltration.

3.5 Test conducted in lab

Sample	Time to absorb all water	Residual dry bentonite (gm)	Unabsorbed water in cc	Average break pressure for 6 test specimen
BH* 40	12	12.56	0	4.6
BH *40 =95% and BH *50 =5%	10	15.57	15.57	-
BH *40 =90% and BH *50 =10%	8	16.35	16.35	-

Cut back emulsifier

Compaction alone yielded 40 percent of run-off over the catchment. however if one coat of bitumen on compacted earth gave yielded 65 percent of runoff and two coats of bitumen after compaction gave yielded 89 percent of run-off. Further cost analysis is subjected for store quantity of water during rainy season. The river bed also become single and double coat over the large basement to retain water in the reservoir, dam and hydraulic structure. The increasing rate of sinking become one of the measure concern to avoid the sinking and increasing the rate of storage, method is suited.

3.6 Waterproof Membranes

Emulsion, Flexible membranes as well as concrete membranes are used as water membranes. However the concrete membranes with the bentonite ratio up to 30 to 35 % is giving the higher rate of ground improvement, further electrical resistivity method is adopted for innovation of large catchment of Hydro power dam , reservoirs and long life .

B_ Methodology for the minor treatment work involved

3.7 i**) Removal of plantation from the catchment areas**

In the annual intensity of rain fall of 250mm and removal of vegetation leads to decreasing the infiltration rate 40-50% and decreasing of infiltration rate increased the 7 to 21 % of runoff rate. The reason for this effect is partly that the plant cover gives protection against the rain-drop impact and lessens the crusting effect, while the plant roots and surface increase the infiltration.

ii) Removal of stones from the soil

A superficial analysis of the hydrology would suggest that, if the soil surface is covered with a significant amount of stones, the run-off from this impermeable surface would increase the overall run-off. The coefficient of run-off is not always as high as might be expected from bare rock surface, and can go down to less than 50 percent due to losses from evaporation, surface depression storage, and losses through fissures and cracks. Limestones are usually weathered and fissured, and may yield as little as 25 percent, while a steep solid granite may yield 80 or 90 percent. The yield can sometimes be increased by sealing the fissures with cement or bitumen.

4.0 Water Storage

The harvesting and use of water by storing it in dams, spillway for the generation of Hydro power plant , reservoir for thermal power plant , Hydraulic structure for irrigation as well as storage of water for drinking purpose .

4.1 Spillways: The model of few dams on streams and rivers can be built big enough to store all the run-off, and some provision is required to pass on the surplus flood water after the dam has filled. The spillway is constructed adjacent to the reservoir as shown in figure 1.6, section of concrete with mixing of 30 % bentonite ratio to avoid the increasing rate infiltration at the base of foundation . It is wise to limit the maximum size of catchments for dams with sealed of bentonite ratio of the slurry 4-7% and geo membranes with concrete over spillways to 500 ha in semi-arid areas.

I. Model-I River based Hydro power storage dam, thermal power reservoir storage and drinking storage dam

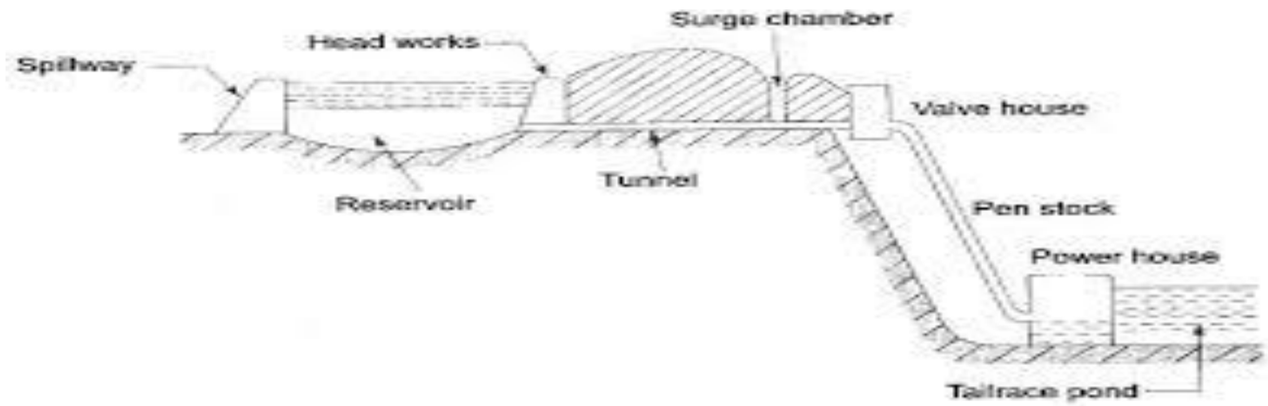


Fig. 1.6 A typical layout for a storage type hydro plant

The basic concern to provide the impervious floor just below the dam and reservoirs and spillway by adopting the recent trend of mixing the betononite slurry in the soil and as well as cement with sufficient pressure with an observation of back pressure during the test procedure . Normally the bentonite concrete ration for the concrete mix floor being adopted more than equal to 30 %. But a further study over the different condition of strata, the electro osmosis or electrical resistivity test based on the properties of soil being conducted for impervious floor .But the floor of spillway must be restricted to 500 ha.

The method of mixing ingredient from preventing the surface water into the ground water table are generally 4 to 7 % bentonite slurry out of a water quantity of 68 to 88 % . However cement without replacement become 8-25%, when blast furnace are also added become 1-3% and when fly ash is also added, the quantity of the fly ash are added as 2-7 % . If blast furnace slag are used , the % of the blast slag are taken as 7-22 % , however fly ash are added 6-18% . The above mix gradient is subjected with the catchment of river basin to avoid the increasing rate of infiltration. .

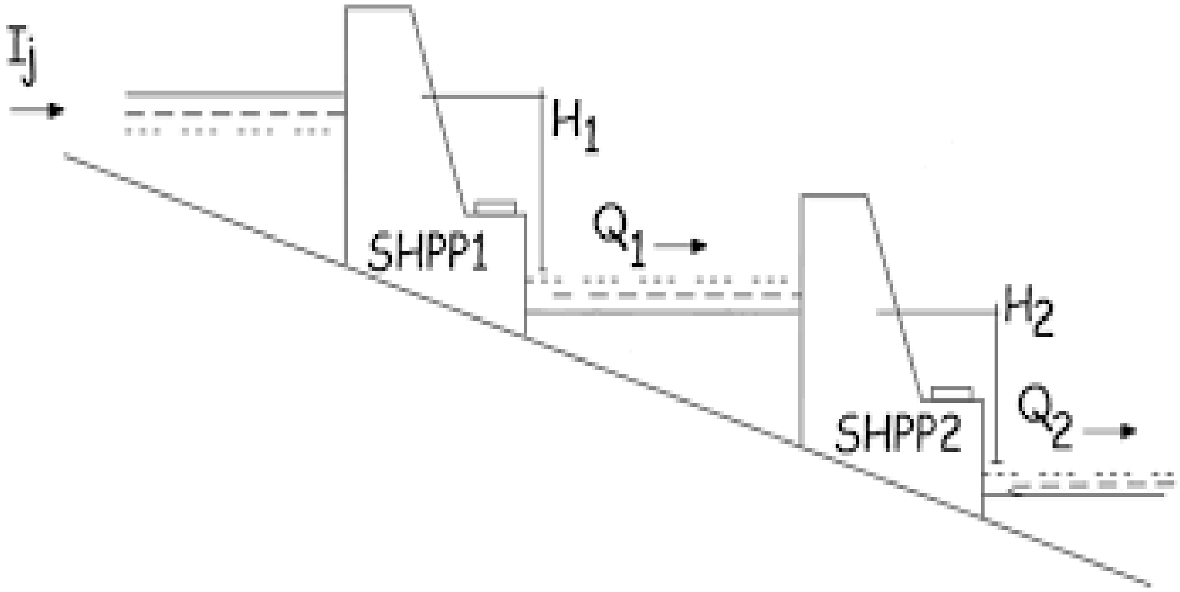
b. **Natural spillways**

These are used where the site conditions make it possible to divert the flood flow into a naturally existing waterway or channel but the floor of the natural spillway is required to be sealed with bentonite slurry with 4-7 % as well as other ingredient as given in the methodology to avoid infiltration rate of the soil during the peak hours of floodin.

c**. Mechanical spillways**

These use pipes to pass the flood through the embankment. It would not be practical to have the pipe large enough to pass the maximum peak flow, so temporary flood storage is provided above the pipe outlet. This Drop inlets are often used at the entry to pipe spillways, partly to ensure a good discharge through the pipe and partly so that the pipe can be buried below the dam wall,

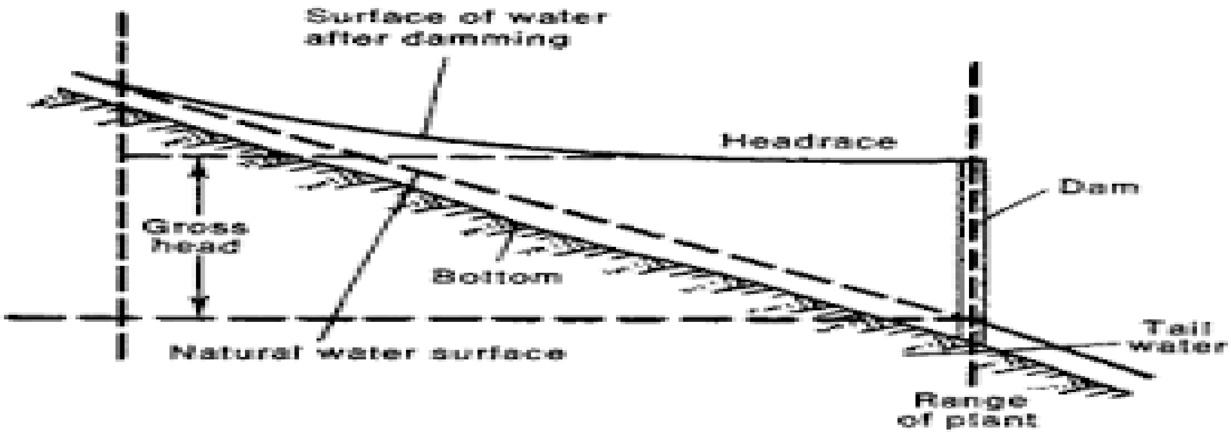
II. Model-II River based Hydro power storage dam, thermal power reservoir storage and drinking storage dam



The preventive and remedies of the sinking of water table below the ground water to provide the impervious floor below the Hydro power dam and spillway i.e. the extraction of sample by providing the boring as mention for cohessionless soil and cohesive soil, after the extraction of the above soil, soil and sand sample are tested in lab by mixing the 30- 35 % bentonite mixed concrete is a promising grounding improvement material based on experimental readings. The different two three country chemicals being tested in laboratory with different batch.

The method of mixing ingredient such as bentonite slurry , water the quantity of fly ash blast furnish and slag are added in the slurry to provide the impervious floor and the decades of sinking of water does not effect the storage capacity of water in the reservoir , dam etc. The mixing are generally 4 to 7 % bentonite slurry out of a water quantity of 68 to 88 % . However cement without replacement become 8-25% , when blast furnace are also added become 1-3% and when fly ash is also added , the quantity of the fly ash are added as 2-7 % . If blast furnace slag are used, the % of the blast slag are taken as 7-22 % , however fly ash are added 6-18%. The above mix gradient is subjected with the catchment of river basin to avoid the increasing rate of infiltration.

III. Model-III River based Hydro power storage dam, thermal power reservoir storage and drinking storage dam



The methods are based electrical resistivity and best suited for impervious floor design, depending on the strata condition the chemicals ingredient are mixed. The different two three country chemicals being tested in laboratory with different batch. The catchment areas of river basin are limited to 500-600 ha in case of Hydro power plant. But the sinking provision of storage water level effect during the low rate discharge of water. The storage capacity tends to decease during the peak discharge rate also even the basin of river become recharge and providing water harvesting. Hence a impervious floor for the river basin is needed.
The method of mixing ingredient from preventing the surface water into the ground water table are generally 4 to 7 % bentonite slurry out of a water quantity of 68 to 88 % . However cement without replacement become 8-25%, when blast furnace are also added become 1-3% and when fly ash is also added , the quantity of the fly ash are added as 2-7 % . If blast furnace slag are used, the % of the blast slag are taken as 7-22 % , however fly ash are added 6-18% . The above mix gradient is subjected with the catchment of river basin to avoid the increasing rate of infiltration.

b. Side slopes

The embankment walls should be not steeper than 3:1 on the upstream side and 2:1 on the downstream. For soils approaching the ideal mixture of grain sizes and which are carefully placed and well compacted, the slopes could be increased to 2:1 upstream and 11/2:1 downstream. Soils which will be difficult to compact should have slopes of 3:1 or 4:1.

Crest width; The top of the dam wall must be wide enough for both the construction equipment and for any traffic if the wall is going to be used as a bridge. Width of 2 m will be enough, but for vehicles a minimum of 3 m should be allowed.

Settlement; An average soils with reasonable compaction 10 percent should be added to the finally required height. This means that the newly built wall will be convex along the top as the allowance for settlement will be greater in the middle than at the ends.

Hafirs and tanks

The tanks are frequently multi-purpose, being for combinations of domestic use, stock consumption, fish production, and irrigation. Deep water pools are sometimes provided within the tank so that fish can survive between rainy seasons, with no fishing permitted in these sanctuary pools.

Rectangular tanks; This is the best shape for gently sloping land and can give S/E ratios of 1.5 to 2.5. Catch drains pick up surface run-off, and when the reservoir is full any surplus is spilled safely through overflows in the catch drains. These are also called tank-dams. Small sizes for stock watering can be built economically using either a drag-line excavator, or a small farm tractor and scoop, or by hand.

Ring tanks ; On flat, or nearly flat ground, better S/E ratios are obtained from round tanks rather than square tanks Because of the geometry of this shape, the S/E ratio increases with size, being about 1.5 for a 50 m diameter tank holding about 35 000 m^3 to 4.5 for 200 m diameter holding 200 000 m^3.

Turkeys nest tank: if the surface soil is relatively impermeable, but overlies a more porous material, or · where it is convenient to be able to distribute the water by gravity.

The S/E ratio is poor, from 0.2 at 200 m^3 to 0.4 at about 5000 m^3, and the main use is as an alternative to corrugated-iron storage tanks for small quantities of pumped water used for stock watering.

Storage below Ground Level

A modern variation was tested and developed with principle is to excavate a cistern or tank, and line it with simple building blocks called 'sausages' which are made by filling plastic tubing with a mixture of sand and cement. The sausages are placed in position while dry and flexible and later set to form a rigid wall. Plastic sheeting is also used to make a waterproof membrane liner on the outside of the plastic sausages

DEVELOPING GROUNDWATER

Deep storage and extraction. Is kind of developing the ground water.

Groundwater Recharge

The possible sources of water for recharge are spate flows in streams and rivers, run-off collected by furrows or channels, and run-off stored in tanks or dams. The conditions required for recharge to be practical are: · adequate surface infiltration for the water to be absorbed, and permeability so that it can move below the surface;· good water storage capacity. For rock this is defined as the specific yield, or the volume of water which drains from the rock under gravity. It is expressed as a percentage of the total rock volume, and is similar to the porosity of soils. In rocks it depends on the amount of weathering, joints, cracks, and fissures;· good hydraulic conductivity is required: the rate at which water can be abstracted from or recharged into the rock depends upon its hydraulic conductivity.

Two problems which may occur with recharge are salinity and silting. Storm run-off and flood water in streams and rivers are usually low in salts because of the dilution, although there are cases of semi-arid saline soils where even the flood run-off is saline. The more common problem of salinity is where raising the water table brings up saline groundwater to within the reach of wells or plant roots.

Silting may be a problem because the flash run-off in semi-arid areas usually carries a heavy sediment load which is likely to block the soil surface and reduce infiltration. Siltation tanks are commonly used to reduce this problem, for example, in the systems of recharging groundwater in the San Joaquin Valley in California.

Methods of recharge: The methods of water spreading discussed in Section 5.3 may be used also for groundwater recharge, either by carrying run-off to an infiltration zone, or it may happen almost accidently by seepage through the bottom of canal. Accidental seepage from canals may be beneficial where a rise in the water table is helpful, but it can also lead to undesirable results by causing water logging or salinity problems.

Conclusion of the technical paper

1.The rate of water sinking as stated in the technical papers indicating with respect of Qutub are varying drastically from 66 ft to 805 ft in the year of 2025 is the measure concern .

2. The variation of the water table are approximately initially 1.5 Times, 2 times, 3 times and 4 times of last 60 years (i.e. 15 years graphical representation were shown).

3. The increasing rate of depletion and increasing rate of infiltration in the soil giving the reduction of storage capacity of dam, reservoir etc is the measure concern of the present concern.

4.The storage for the irrigation and Hydro power generation based on the population during the decades 2015-2020 are 350 gallons per day , however the water available was too less as compared to requirement, it is due to the sinking of water level below the ground water table, hence recharging the basin also should not full fill the requirement.

5.The storage for the thermal based on the population during the decades 2015-2020 are 400 gallons per day , however the water available was too less as compared to requirement , it is due to the sinking of water level below the ground water table, hence recharging the basin also should not full fill the requirement

6. The storage of water in reservoir for Improvement of water quality of water through dilution

7. The Storage of waste water and sewage for removal of bacteriological and other impurities , so that the water may re-use .

8. The preventive and remedies of the sinking of water table below the ground water to provide the impervious floor below the Hydro power dam and spillway i.e.. 30- 35 % bentonite mixed concrete is a promising grounding improvement material based on experimental readings. Although there is no clear relation between volume of bentonite and the grounding resistance value, 30% by volume is the ideal proportion when mixing bentonite with concrete are made. The method is based electrical resistivity and best suited for impervious floor design, depending on the strata condition the chemicals ingredient are mixed. The different two three country chemicals being tested in laboratory with different batch.

9.The method of mixing ingredient from preventing the surface water into the ground water table are generally 4 to 7 % bentonite slurry out of a water quantity of 68 to 88 % . However cement without replacement become 8-25% , when blast furnace are also added become 1-3% and when fly ash is also added , the quantity of the fly ash are added as 2-7 % . If blast furnace slag are used , the % of the blast slag are taken as 7-22 % , however fly ash are added 6-18% . The above mix gradient is subjected with the catchment of river basin to avoid the increasing rate of infiltration. .

Reference

1. Alley, W. M., T. E. Reilly, and. O. E. Franke. (1999). Sustainability of groundwater resources. U.S. Geological Survey Circular 1186, Denver, Colorado, 79 p. *http://pubs.usgs.gov/circ/circ1186*
2. Alley, W. M. (2003). Desalination of Ground Water: Earth Science Perspective. Fact Sheet 075-03, U.S. Geological Survey, Denver, Colorado. *http://pubs.usgs.gov/fs/fs075-03*
3. Alley, W. M., and S. A. Leake. (2004). The journey from safe yield to sustainability. Ground Water, Vol. 42, No.1, January-February, 12-16.
4. Freeze, R. A., and J. A. Cherry. (1979). Groundwater. Prentice-Hall, Inc., Englewood Cliffs, New Jersey.
5. Fuhrer, G. J., R. J. Gilliom, P. A. Hamilton, J. L. Morace, L. H. Nowell, J. F. Rinella, J. D. Stoner, and D. A. Wentz. (1999). The Quality of Our Nation's Waters -- Nutrients and Pesticides. U.S. Geological Survey Circular 1225, Reston, Virginia, 82 p. *http://pubs.usgs.gov/circ/circ1225*
6. Galloway, D., D. R. Jones, and S. E. Ingebritsen. (2001). Land subsidence in the United States. U.S. Geological Survey Circular 1182, Denver, Colorado, 175 p. *http://pubs.usgs.gov/circ/circ1182*

7. Hardin, G. (1968). The Tragedy of the Commons. *Science*, Vol. 162, 1143-1148.
8. Jones, A. A. (1997). Global hydrology: Processes, resources, and environmental management. Longman, England.
9. Love, A. J., P. G. Cook, G. A. Harrington, and C. T. Simmons. (2001). Groundwater flow in the Clare Valley. Department of Water Resources, Government of South Australia, Adelaide, Australia.
10. L'vovich, M. I. (1979). World water resources and their future. Translation of the original Russian edition (1974), American Geophysical Union, Washington, D.C.
11. Meinzer, O. E. (1927). Plants as indicators of ground water. U.S. Geological Survey Water-Supply Paper No. 577, U.S. Government Printing Office, Washington, D.C.
12. National Research Council. (1996). Rock fractures and fluid flow: Contemporary understanding and applications. U.S. National Committee for Rock Mechanics, National Academy Press, Washington, D.C.
13. National Research Council. (2000). Investigating groundwater systems on regional and national scales. Committee on USGS Water Resources Research, National Academy Press, Washington, D.C.
14. Natural Resources Conservation Service. (2005). Chapter 19: Transmission Losses. National Engineering Handbook, Part 630, Hydrology, Washington, D.C.
15. Ojos Negros Research Group. (2003). Sustainable management of water in the Ojos Negros basin, Baja California, Mexico. San Diego State University, San Diego, California. *http://ponce.sdsu.edu/ojosnegrosreport.html*
16. Ponce, V. M., A. K. Lohani, and P. T. Huston. (1997). Surface albedo and water resources: Hydroclimatological impact of human activities. *Journal of Hydrologic Engineering*, ASCE, Vol. 2, No. 4, October, 197-203. *http://ponce.sdsu.edu/albedo197.html*
17. Ponce, V. M., R. P. Pandey, and S. Ercan. (2000). Characterization of drought across climatic spectrum. *Journal of Hydrologic Engineering*, ASCE, Vol. 5, No. 2, April, 222-224. *http://ponce.sdsu.edu/droughtasce222.html*
18. Sophocleous, M. (2000). From safe yield to sustainable development of water resources - The Kansas experience. *Journal of Hydrology*, Volume 235, Issues 1-2, August, 27-43.
19. The World Commission on Environment and Development (The Brundtland Commission). (1987). Our Common Future. The United Nations, New York.
20. World Water Balance and Water Resources of the Earth. (1978). U.S.S.R. Committee for the International Hydrological Decade, UNESCO, Paris, France.