PUMPING OF FRESHWATER AND GENERATING ELECTRICITY: TWO PROPOSAL OF UTILIZING SHARAVATI RIVER ESTUARY

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Abstract - *Estuary can be defined as, "A partly enclosed coastal body of water in which river water is mixed with sea water". Freshwater is much lighter than the seawater due to its density, which make them to float over the seawater in the estuarine region. Latterly they get intruded into seawater through tidal waves. West coast of India is a thrust area to study about the estuarine region as they have bounty of rainfall, the greatest number of rivers and water falls. For present study, coastal region of Honnavar taluk, Uttara Kannada Dist. viz., Sharavati river estuary has been taken. As the river along with its longest flow, brings plenty of rain fall throughout the flowing region and finally meets Arabian sea which ultimately leads to flooding in surrounding area during rainy season and drying up of land as well as salt water intrusion in groundwater due to coastal calamities in summer. The conventional approach of constructing dams or desalination is not economically viable for usage of water and causes ecological imbalance in estuary. Hence, a short range of solution can be used to store water, prevent flooding and loss of river water to ocean in rainy season, and water scarcity in summer. i.e., pumping of freshwater from the estuary during the period of it floats above the salt water before intrusion by applying self-harnessed electricity in the same region by suitable method.*

Key Words: **estuary, intrusion, seawater, water pumping, freshwater, self-harnessed.**

1. INTRODUCTION

Earth climate is at its warm-point in the glacial and inter glacial cycle, and sea level is high as ocean covers 71% of earth's surface. As a result, lowest reach of many river valley is flooded creating elongated bodies of water grading from salt to fresh water. The place where this salt water meets freshwater is called as an estuary. Density of seawater is more than freshwater making them to float above the sea water in the estuarine region for some period of time and latterly they get intruded into seawater through tidal waves.

The west coast of India is a thrust area to study about the estuarine region as they have bounty of rainfall, most number rivers and water falls. For present study, coastal region of Honnavar taluk viz., Sharavati river estuary has been taken. As the river along with its longest flow, brings plenty of rain fall throughout the flowing region and finally meets Arabian sea which ultimately leads to flooding in surrounding area during rainy season and drying up of land as well as salt water intrusion in groundwater due to coastal calamities in summer. The conventional approach of constructing dams or desalination is not economically viable for usage of water and causes ecological imbalance in estuarine biodiversity. Hence, a short range of solution can be used to store water, prevent flooding and loss of river water to ocean, and water scarcity in summer. i.e., pumping of freshwater from the estuary during the period it floats above the salt water before intrusion by applying self-harnessed electricity in the same region by suitable method. The sites for the proposed project are selected considering the researches made on respective estuary, where it had been divided into three parts according to the water flow and salt water intrusion. Also, based on the study of salt water intrusion tidal waves, tidal generator, power conversion etc.

1.1. OBJECTIVES

The primary objectives of this study are to pump freshwater present in the estuary within certain time with self-generating power. The specific objectives of this work include:

- To study the selected area its topographical and geographical aspects and percentage of possibilities of proposed project.
- To assess quality and quantity of estuary water for selected area by calculating the water quality index using the various parameters.
- To study soil parameters on banks of the selected site region and nearby places to know the water quantity present in soil for construction of storage tank onshore.
- To select site for placing tidal stream generators and pump by planning the area within estuarine region.
- To asset the capacity of pump and power to be generated from tidal waves.
- Utilizing the pumped water for drinking and other domestic purpose.
- Designing of pipelines and storage tanks and service storages for the proposed town to distribute water.
- Estimating the cost effect.

2. LITERATURE REVIEW

With reference to the sourced information, we can summarize that only limited quantity of water can be withdrawn from the estuary before it gets completely mix with sea/ocean. Since, saltwater intrusion is the major concern when freshwater extraction is located in estuary because the concentration of salinity of freshwater and sea water is 0 and 35 ppt respectively and the salinity of freshwater in estuary ranges from 0.5 to 35 ppt. as the depth of intrusion varies with respect to time period. Desalination is restricted to coastal areas only and large-scale water transfer is very expensive. Alternately, a short-range solution can be used for the storage as well as for flooding of water by pumping of freshwater from estuary through self-harnessed generating power which can contribute 6GW to 12GW of clear power per day using tidal stream generator instead of barriers avoiding ecological imbalance as many birds, animals and plants are adapted to the habitat of estuarine belt. The obtained fresh water is in its purest form as the primary treatment of water is done naturally by mangrove trees and other necessary filtration can be done through reverse osmosis process through which excess of minerals and salts can be extracted and can be used for fertilization of soil, after this water can be stored and supplied to the surrounding region as well as can be used for agriculture and industrial purposes. The main advantage of this purpose is to avoid a greater number of borewells through which we can restore ground water.

3. ABOUT THE SITE

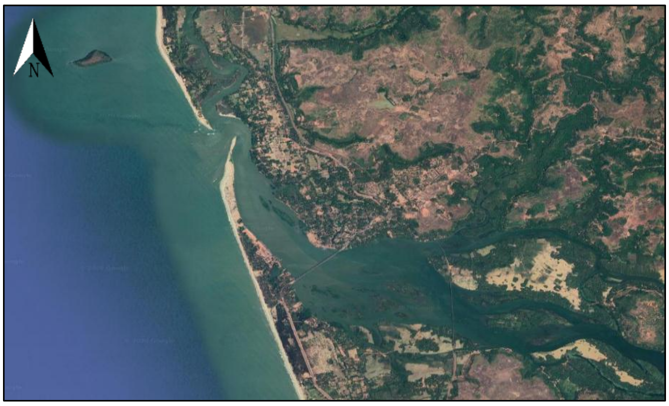


Fig - 1: Geographical Image of Site

The Sharavati also called as Gersoppa or Banaganga river has its origin at Ambutirtha (75° 11' E: 13° 47' N) near Nonabar in Tirthahalli taluk of Shimoga district. After a northerly course for about 64 km from Nagar, it forms the South-East boundary of Uttara Kannada for about 13 km and then passes towards West, covering 134 km in all to join the Arabian sea at Honavar. Soon after touching the border of Uttara Kannada, the river in four different bodies of water among magnificent forests and wild granite cliffs, dashes over the West face of Sahyadris, at a height of 252 meters into a pool of 117 meters deep. This is the famous "Jog Falls". About 30 km. West, from the Jog Falls it reaches the village Gersoppa. During the remaining 27 km from Gersoppa village to the coast, the river flows between richly wooded banks fringed with mangrove bushes, a broad tidal estuary, brackish in the dry weather but during the rains, sweet even close to its mouth. About 8 km from its mouth, the river widens to a lagoon about three km broad, containing a few islands, the longest being Mavinkurve which is more than five km long with a large area of paddy land and studded with mango and coconut trees. For about two km from the mouth, the river has a breadth of about 1.5 km. At the mouth, it narrows into a channel about 275 meters broad. Outside of it lies a formidable and changing sand bar. The island Pavinkurve at its mouth near Honavar has been completely washed off recently and the river has been depositing sand at Kasarkod on the left bank of its mouth.

The length of the Gersoppa gorge is about 24 km Passing along the road from Talaguppa to Gersoppa occasional glimpses of the gorge can be had showing clearly the even skyline of the plateau incised and wedged apart by the river into a deep and narrow canyon. The lowering of the river bed is so rapid that the valley has had no time to widen, and therefore, appears in the form of a deep gorge with perpendicular faces. Tributary streams unable to keep pace with the rapidly eroding channel of the main stream have hanging valley ends through which water glides down in minor waterfalls.

4. MARETIALS REQUIRED

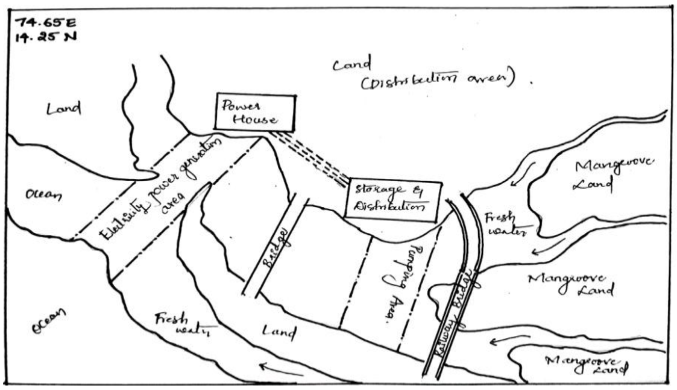


Fig - 2: PLAN

Fig - 3: Station Location

According to the plan, and preliminary study about the estuary water as sampling stations the project site is divided into 4 areas,

STATIONS	LOCATION CO-ORDINATES	
	Latitude (E)	Longitude (N)
1	74° 25' 30"	14° 18' 00"
2	74° 26' 21"	14° 16' 30"
3	74° 26' 58"	14° 16' 25"
4	74° 27' 12"	14° 16' 23"

Table - 1: Co-Ordinates of Station Locations

1. Electric Power Generating Area
2. Power House
3. Water Pumping Area
4. Water treatment and distribution plant

These areas are named based on their working process in the site the equipment's required for particular area is noted down briefly:

4.1. TIDAL STREAM GENERATOR

Tidal stream generators look and work like underwater wind turbines. As opposed to using the rising and falling movement of the tides, tidal stream generators take advantage of the fast-moving sea currents (tidal streams), which flow when tides are moving in and out. These tidal streams cause the turbines to rotate, turning the generators to generate electricity. Tidal stream generators have the advantage of being much cheaper to build, and do not have as much of an environmental impact as a tidal barrage. The turbines turn relatively slowly, hence do not affect sea life. This is different to tidal barrages, which can disrupt fish migrating up rivers from the sea. These tidal stream generators draw energy from currents in much the same way as wind turbines. The potential for power generation by an individual tidal turbine can be greater than that of similarly rated wind energy turbine. The higher density of water relative to air (water is about 800 times the density of air) means that a single generator can provide significant power at low tidal flow velocities compared with similar wind speed. Given that power varies with the density of medium and the cube of velocity, it is simple to see that water speeds of nearly one-tenth of the speed of wind provide the same power for the same size of turbine system; however this limits the application in practice to places where the tide moves at speeds of at least 2 knots (1 m/s) even close to neap tides. Furthermore, at higher speeds in a flow between 2 to 3 meters per second in seawater a tidal turbine can typically access four times as much energy per rotor swept area as a similarly rated power wind turbine.

Fig - 4: Tidal Stream Generators

The operation and execution of tidal power plant is more difficult. This reasonable execution happens partially in light of the fact that every turbine remains alone without the requirement for a monstrous dam as in the tidal torrent framework. Such measured quality likewise takes into consideration smaller applications to be developed once the monetary practicality is settled in a little test venture and once natural effects are better caught on. One of the key preferences of tidal stream generators is the capacity to consolidate them into existing structures such as scaffolds and docks. This further lessens the cost as well as decreases the natural effect. It captures the energy of the tide by placing the generator into the path of flowing water and is currently known as the 1.2 MW. It has the capacity to deliver about 10 MWh per tide which is equivalent to 6000 MWh per year.

4.2. MARINE CABLES

Marine cables facilitate the transfer of power from the OEC to the onshore grid. In addition to transferring power, marine cables serve the crucial role of transmitting communication signals between the array equipment and the shore, which are vital for monitoring and control of electrical components within the network. Cables are classified into two categories: static cables and dynamic cables. This classification is essentially defined by the expected movement of the cable: static cables are typically buried within the seabed, or secured to the surface using external protection, while dynamic cables will operate in the water column.

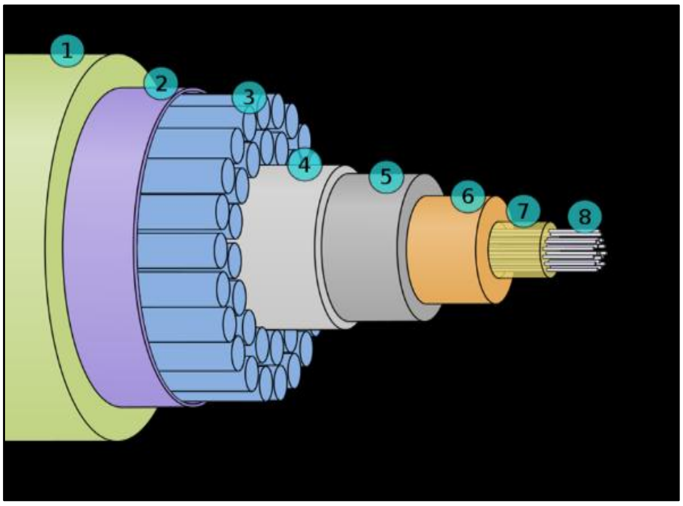


Fig - 5: Cross-Section of Marine Cables

A Cross-Section of the shore-end of a modern Marine Cable.

1. Polyethylene
2. Mylar tape
3. Stranded steel wires
4. Aluminium water barrier
5. Polycarbonate
6. Copper or aluminium tube
7. Petroleum jelly
8. Optical fibres

1. STATIC CABLES

Static power cables are used to collect the power generated by the farm through the intra-array electricity network and also to export the generated power from the collection point to the shore. They were used to the extraction of power generated offshore and deliver power across small stretches of water. The functional capability of static cables far exceeds the current requirements. However, there are several specific challenges, which result from the high-energy environments, which must be considered. One impact of this is during the installation phase, regarded as one of, if not the most high-risk phases of the cable lifetime.

2. DYNAMIC CABLES

Dynamic cables are used to transfer the power generated by floating OECs to the subsea network and may also be required at the transition to stationary structures (such as fixed tidal turbines or surface piercing substations). The main point of difference with static cables is that double layer armouring is considered standard for dynamic cables in order to provide hydrodynamic stability during installation and operation phases. These cables are designed with high axial tensile and compressive strengths to maximise conductor fatigue resistance during installation and service. MV power cables with conductor size up to 400 mm have been used. Their use has been reported in water depths exceeding 1500 m. the dynamic cables are essential to a floating wind farm as they transport the electrical power produced at the floating platforms, which are designed for water depths >50 m.

3. CONNECTOR

Connectors allow for a non-permanent connection of different parts of the electrical system, facilitating the recovery of devices and components for maintenance. Connectors are used to connect two cables or a cable to another piece of electrical equipment within marine energy farms. Connectors are classified based on whether they are mated in a dry or wet environment, i.e., above or below the water surface, as dry-mate and wet-mate connectors.

4.3. POWER CONVERTING DEVICE

After generating power from the turbine, the next process was to convert the energy into necessary form which can be used to pump freshwater from the estuary. A number of challenges were immediately apparent such as how to deliver to the pump house at minimal losses and also the fact that elements of the power conversion equipment would be placed offshore through some cable connection and how to protect the device and sea bed cables during wave activity caused by storm condition. The power conversion house or the power house on the shore consist of the step-up transformer connected to the generator which transmitted power via the mooring swivel slip rings to an umbilical cable to minimise the transmission loss, then the stepdown transformer is allowed connection to local grid connection point. Other two transformers were connected up with the test length of sub-sea cable, together with the optimal designed shore control panel, such that as the electricity generated can be used for pumping of water as well as to produce electricity the to the nearby town or cities in necessary condition.

(a)

(b)

Fig - 6: (a) and (b) Development Test Ring with The Sub-Sea Transformer and The Power Conversion Equipment

The above images show the complete development test ring with the sub-sea transformer within the yellow enclosure. The power conversion equipment is shown located within the equipment skid and the shore transformer, shore control panel and test drive are also shown.

4.4. MARINE PUMPS

Marine pumps designed as centrifugal pumps perform a great variety of duties on board (see Pump application): in the engine room as a boiler feed pump, condensate pump and cooling water pump using seawater or fresh water, in the bow as a transverse thruster, in special pump rooms as a cargo oil pump, Butterworth pump or ballast pump, for special duties as an anti-rolling, anti-heel or trimming pump, as a bilge pump or stripping pump, as a fire-fighting pump, and as a service pump for a variety of applications. Dock pumps are also classified as marine pumps. Cooling water pumps using either seawater or fresh water and fire-fighting pumps draw in fluid from the sea chests via suction lines. Sea chests are tanks mounted to the inner side of the ship's hull below the water line. Their apertures face seawards and are covered by inlet screens.

The power/ electricity needs to pump water is being generated and being transmitted to the pump station by the means of cables as both the sites are kept far apart for safety purpose. If the fluid handled is seawater, suitable pump material is required: gunmetal or bronze (e. g. multi-alloy aluminium bronze) for the pump casing and impeller, and chrome nickel steel for the pump shaft. As bilge and ballast water lines often require large quantities of air to be evacuated, many of the pumps on board are self-priming pumps. They are water ring pumps which rotate continuously with the main pump. Separate bleeding devices such as ejectors or central vacuum systems are also gaining in popularity. Due to the restricted installation space on board the most suitable design for the majority of marine pumps is a vertical pump in radially split design with the motor mounted directly on top.

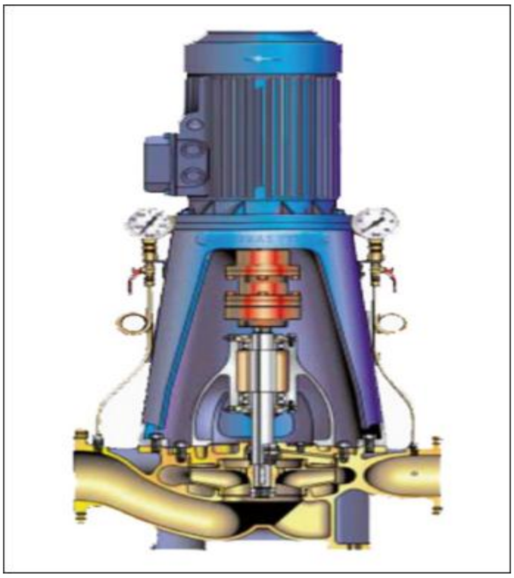


Fig - 7: Radially Split Vertical Marine Pump

4.5. PURIFICATION MATERIAL

The general materials used in purification process are:

a. ION EXCHANGE RESIN:
An ion-exchange resin or ion-exchange polymer is a resin or polymer that acts as a medium for ion exchange. It is an insoluble matrix (or support structure) normally in the form of small (0.25–0.5 mm radius) microbeads, usually white or yellowish, fabricated from an organic polymer substrate. The most common examples are water softening and water purification. They are divided into 4 types as strongly acidic, strongly basic, weakly acidic and weakly basic.

b. COAGULANTS:
Hydrolysing metal salts, based on aluminium or iron, are very widely used as coagulants in water treatment. These materials play a vital role in the removal of many impurities from polluted waters.

c. SODIUM HYPOCHLORITE:
Sodium hypochlorite (NaOCl) is a compound that can be effectively used for water purification. It is used in the chlorination process. It is used on a large scale for surface purification, bleaching, odour removal and water disinfection.

d. CARBONACEOUS MATERIAL:
Carbon filtering is commonly used for water purification. Active charcoal carbon filters are most effective at removing chlorine, sediment, volatile organic compounds (VOCs), taste and odour from water. They are not effective at removing minerals, salts, and dissolved inorganic compounds.

e. ANTHRACITE:
Anthracite is an excellent filter media for water clarification in drinking or industrial use, when used in combination with filtering sands. It is one of the most

used filtering media. It is a good complement for the mixed filters, in company of sand or green manganese sand. Due to the special shape of its grains, it allows the suspended particles to be retained in the depth of the filtering bed.

f. SILICA SAND:

The natural silica filtration grade sands have a sub-angular to rounded shape, making them an ideal filtration media to capture suspended solids in water. Due to the high silica content, the sand is extremely durable and hard-wearing, allowing it to be precisely graded to facilitate efficient filtering. The silica sand is usually laid on top of a supporting layer of gravel within the filter vessel. The incoming water enters the filter and migrates through the silica sand, successfully removing any solids or debris from the water.

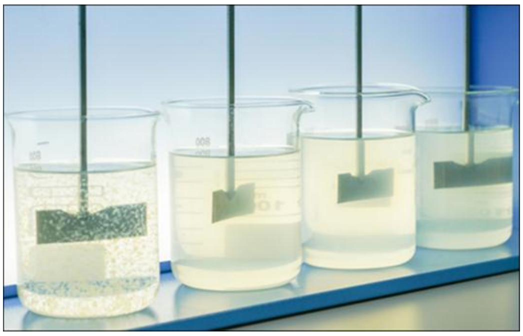
g. GARNET:

Garnet is an ideal water filter media. Garnet is a chemically inert and non-metallic mineral, which is commonly found in the natural environment. Garnet is well known for its hardness and durability. It has a high specific gravity as well as its chemical and abrasive resistance makes garnet an ideal filter media. This product occurs both in large sizes conducive to support beds, and in smaller sizes for cap beds and is dense enough to allow faster back flushing.

h. MERCURY ARC LAMP:

For most practical UV applications in water treatment today, the light is generated by a mercury vapor lamp, or in a gas mixture that contains mercury. Mercury is the gas of choice because the light it puts out is in the germicidal wavelength range. Lamp output depends on concentration of mercury within the lamp, and the concentration depends on pressure.

(a) Ion Exchange Resin



(b) Coagulants

(c) Sodium hypochlorite

(d) Activated Carbon

(e) Anthracite

(f) Silica Sand

(g) Garnet

(h) Mercury Arc Lamp

Fig - 8: Purification Materials

5. METHODOLOGY

According to the preliminary and topographical study about respective estuarine region, the proposed project site was visited. Based on the geographical features of the site, it is marked and divided into four areas as two onshore and two offshore namely power generating, power conversion, water pumping and water treatment and distribution. In conformance with these areas, four stations were selected to collect water samples for water quality test in the estuary. The water samples were collected with respect to seasons at three different depth respectively for all four stations. Parallelly soil samples were also tested onshore at 500m apart from the stations which were roughly selected for water pumping and water harnessing to check the stability and suitability of soil for construction of power house and treatment and distribution plant. Along with these tests, information on population forecasting, station co-ordinates, climatic data for 30 years, capacity of turbines and necessary design for pump, pipelines, and storage tank were also collected and calculated. The water will be distributed in the form of secondary source for urban area only, as the considered region is already having a public water supply and excess of water extraction may lead to the extraction of salt water.

5.1. POPULATION FORECASTING

After fixing the design period, the increase in total population in design period with respect to present population must be estimated .it can be estimated by using any of the methods such as ***Arithmetic Increase Method, Geometric Mean Method, Incremental Increase Method, And Graphical Method*** etc. But in our case, there is no need of estimating the future population as water supply project is restricted to proposed colony and we have considered the population of the colony when it is fully occupied.

As produced electricity and water can be stored, it can also be transported to the nearby town or cities in need nearby to Honnavar taluk.

POPULATION IN PROPOSED AREA

Total number of households in Honnavar Taluk;

2001 = 30,808

2011 = 37,750

Total population;

2001 = 1, 60,331

2011 = 1, 66,264

Increase in population = 5933

%increase in population = 3.7%

Population forecasting for the year 2051 is calculated as follows;

(Considering design period of 30 years from 2021, taking population of the year 2011as reference)

$$P_{2051} = P_{2011} \times \left[1 + \left(\frac{r}{100}\right)\right]^n \quad \ldots\ldots\ldots\ldots \quad [1]$$

$$= 1,66,264 \times \left[1 + \left(\frac{3.7}{100}\right)\right]^4$$

$$= 1,92,270.76$$

$$= \mathbf{1,93,000\ (approx.)}$$

5.2. WATER QUALITY INDEX

Water quality indices aim at giving a single value to the water quality of a source on the basis of one or the other system which translates the list of constituents and their concentrations present in a sample into a single value. One can then compare different samples for quality on the basis of the index value of each sample. A Water Quality Index (WQI) is a means by which water quality data is summarized for reporting to the public in a consistent manner. It is similar to the UV index or an air quality index, and it tells us, in simple terms, what the quality of drinking water is from a drinking water supply.

Table - 2: Water Quality Classification Based on WQI Value

WQI Value	Water Quality
< 50	Excellent
50 -100	Good water
100 – 200	Poor water
200 – 300	Very poor water
> 300	Water unsuitable for drinking

5.3. CLIMATIC INFORMATION

Air temperature begins to increase steadily from the end of February. April and May are the hottest months with mean maximum temperature of atmosphere about 33°C to 34°C and the mean daily minimum about 25°C to 26°C. On individual days the day temperature may rise up to 35°C in the coastal region. Weather during the period, March to May is very oppressive due to the moist heat, which is relieved by cool sea breeze, which blows in the afternoons and thunder showers which occur in the afternoon of some of the days bring welcome relief. With the onset of the South-West monsoon by about the month of June, temperature decreases and weather becomes tolerable. During post monsoon period days temperatures up to the end of December are as high as during the period March to May. The average atmospheric temperature of the Sharavati river estuary area around Honnavar ranges between the maximum 34°C and the minimum 19°C. The relative humidity is generally high throughout the year and more particularly so during the South-West monsoon months (June- September). March-April are the arid months with 30 to 40% rh while it is as high as 90% rh during July-August. Winds are light to moderate with some strengthening in the South-West monsoon season.

Table - 3: Climatic Data

CLIMATE DATA FOR HONNAVAR TALUK (2015-2045)													
Month	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Year**
Record high °C (°F)	35 (95)	35.6 (96.08)	32.9 (91.22)	33.8 (92.84)	34.4 (93.92)	34.4 (93.92)	30.6 (87.08)	30.1 (86.18)	32.1 (89.78)	34.0 (93.2)	35.6 (96.08)	35 (95)	33.63 (92.52)
Average high °C (°F)	31.45 (88.61)	32.52 (90.54)	29.39 (84.90)	33.02 (91.43)	31.95 (89.57)	31.05 (87.89)	28.18 (82.70)	27.16 (80.88)	29.35 (89.83)	30.98 (87.76)	29.69 (85.94)	33.28 (91.90)	30.60 (87.09)
Average low °C (°F)	17.9 (64.22)	17 (62.6)	19.2 (66.56)	25.48 (77.86)	25.67 (78.21)	24.96 (76.93)	23.99 (75.19)	23.95 (75.11)	23.85 (74.93)	22.86 (73.14)	23.53 (74.35)	23.09 (73.56)	22.62 (72.72)
Record low °C (°F)	16 (60.8)	19.62 (67.32)	17.4 (62.24)	23.4 (74.12)	23 (73.4)	22.6 (72.68)	21.5 (70.7)	22.4 (72.32)	22 (71.6)	21.7 (71.06)	21.0 (69.8)	20.4 (68.72)	20.91 (69.65)
Average rainfall mm (inches)	0.0 (0.0)	0.0 (0.0)	1.0 (0.04)	1.1 (0.043)	0.0 (0.0)	721.6 (28.41)	1,630.1 (43.92)	1,477.4 (58.16)	704.2 (27.72)	554.1 (21.81)	27.1 (1.06)	0.2 (0.007)	5113.8 (184.17)
Average rainy days	0.0	0.0	1.0	2.0	0.0	22.0	30.7	30.0	26.4	21.3	2	0.2	135.6
Average relative humidity (%)	57.06	61.03	64.96	70.63	69.64	79.76	87.51	90.80	75.86	81.41	62.93	66.20	72.31

5.4. EXPERIMENTAL PROCEDURES

Water samples which were collected from the respective stations at respective depth for seasons mention were collected in pre-claimed plastic polyethylene bottles, and were immediately stored in the cooler with cold packs after collection. Using the AITM laboratory and Manipal laboratory the samples were tested for the parameters such as colour, odour, pH, acidity, alkalinity, temperature, salinity, iron as Fe, total dissolved solids, total hardness, chlorides, calcium as $CaCO_3$, magnesium as $MgCO_3$, sodium, potassium, conductivity, dissolved solids, turbidity, E.coli. Simultaneously, the soil samples parallel to the assumed stations for power harnessing and water pumping were collected and tested and analysed within one to ten days after collection in order to acquire a complete set of water and soil quality.

5.5. CAPACITY OF TURBINES

Kinetic power in a marine turbine,

$$P = 0.5 \times \rho \times A \times V^3 \quad \text{............ [2]}$$

Where,

A is the cross-sectional area of the rotor section

$$= \left(\frac{\pi}{4} \times D^2\right)$$

ρ is the fluid density,

i.e. density of marine water = 1027 kg / m^3

(Diameter of the rotor section, **D = 15m**)

∴ Cross sectional area of the rotor section $= \left(\frac{\pi}{4} \times 15^2\right)$

$$= \mathbf{176.72\ m^2}$$

V is the tidal current speed ranging from 2-3 m /s

Considering the losses in marine turbine, the total power harnessed is given as;

$$P = 0.5 \times C_p \times \rho \times A \times V^3 \quad \text{............ [3]}$$

Where;

C_p is known as power coefficient.

For marine turbines C_p normally has values between 0.35-0.5

Now;

Considering C_p value as 0.45 and V value as 2.5 m/s

∴ The Total Power Harnessed,

$$P = 0.5 \times 0.45 \times 1027 \times 176.72 \times 2.5^3$$

$$= 638055.84\ kgm^2/sec^3$$

$$= 0.638 \times 10^6\ kgm^2/sec^3.$$

$$= 0.64 \times 10^6\ Watts \text{ (since, 1 Watt = 1kgm}^2\text{/ sec}^3\text{)}$$

$$= \mathbf{0.64\ MW}$$

$$= \mathbf{1\ MW\ (approx.)}$$

Hence, the total power harnessed by using a single rotor turbine is, **P = 1 MW**

Since, minimum three turbines have to be used for water harnessing 3T triton turbine is used;

Therefore, the total power harnessed will be P = 3MW

- Turbine capacity to generate power changes with respect to the diameter of the rotor and number of rotor turbine used in tidal generator.
- Smaller the diameter of the turbine lesser is the power harnessed.

5.6. DESIGN OF PUMP

Let the static lift between water source and storage tank = 40 m

The head loss in pipe, $H_f = \frac{4flv^2}{2gD}$ ………… [4]

Where $f = 0.03, L = 50\,m$

$$V = \frac{Q}{A} \quad \text{…………} \quad [5]$$

$$= \frac{0.185}{\left(\frac{\pi}{4}\times 0.525^2\right)}$$

$$\boldsymbol{V = 0.855\,m/s}$$

$$H_f = \frac{4\times 0.03\times 40\times 0.855^2}{2\times 9.81\times 0.525}$$

$$H_f = \boldsymbol{0.341m}$$

Assuming other minor losses in fitting as 10% 0f frictional loss

= 0.0341 m

Hence,
total head loss = 0.341+0.0341
=0.3751m
Total head required for pumping = 40 + 0.3751
= 40.3751m

Horse Power of Pump $= \frac{\gamma\times Q\times H}{\eta\times 0.735}$ ………… [6]

Assume efficiency of pump, $\eta = 0.8$

$$\text{Power} = \frac{9.81\times 0.185\times 40.3751}{0.8\times 0.735}$$

$$= 124.62\,HP$$

$= \boldsymbol{130\,HP}$ (approx.)

Install five pumps with horse power **= 130 HP**
(4 will be working and One will be used as standby)

5.7. DESIGN OF PIPELINES

As the proposed project is located in Honnavar taluk so, the design of pipeline for the distribution of water is done only to Honnavar taluk.

a. DESIGN OF MAIN PIPELINES

Total population in Honnavar Taluk in 2011 $= \boldsymbol{1,66,264}$
Total population in Honnavar after 4 decades (2051) $= \boldsymbol{1,93,000}$
(using geometric mean method)

Total demand of water $= 193000\times 150$
(assuming per capita demand as 150 liters for domestic usage and fire demand)

$$= \boldsymbol{28,950\,m^3/day}$$

Maximum daily demand $= 1.5\times 28{,}950$

$$= 43425\,m^3/day$$

$$\boldsymbol{Q = 0.503\,m^3/sec}$$

Using Lea's formula, $D = 1.22\sqrt{Q}$ ………… [7]

$$= 1.22\sqrt{.503}$$

$$= \boldsymbol{0.865\,m}$$

$$= \boldsymbol{34.05\,inches}$$

Therefore, adopt diameter = **35-inch** pipe

Velocity, $V = \frac{Q}{A}$

$$= \frac{0.503}{\left(\frac{\pi}{4}\times 0.865^2\right)}$$

$$= \boldsymbol{0.856\,m/sec}$$

b. DESIGN OF SUB MAIN PIPES FROM MAIN TO BRANCH DISTRIBUTOR

Total population $= \frac{193000}{2}$

$= \boldsymbol{96,500}$ (dividing area into 2 blocks)

Maximum daily demand, $Q = 96{,}500\times 150$

$$= 14{,}475\,m^3/day$$

$$= \boldsymbol{0.168\,m^3\,/sec}$$

Using Lea's formulae, $D = 1.22\sqrt{Q}$

$$= 1.22\sqrt{.168}$$

$$= \boldsymbol{0.499\,m}$$

$$\boldsymbol{D = 19.66\,inch}$$

Adopt diameter = **20-inch** pipe

Velocity, $V = \frac{Q}{A}$

$$= \frac{0.168}{\left(\frac{\pi}{4}\times 0.499^2\right)}$$

$$= \boldsymbol{0.859\,m/sec}$$

c. DESIGN OF RISING MAIN

Maximum daily demand = 14,475 m^3/day
The water to be pumped in to tank in 3 hours = 2000 m^3
Hence the water to be pumped to tank per sec $= \frac{2000}{3\times 60\times 60}$

$$= \boldsymbol{0.185\,m^3/sec}$$

The economical diameter of rising main,
Using Lea's formula, $D = 1.22\sqrt{Q}$

$$= 1.22\sqrt{0.185}$$

$$= \boldsymbol{0.525\,m}$$

D = 20.67 inch

Therefore, Adopt diameter = **21-inch** pipe

5.8. DESIGN OF RECTANGULAR STORAGE TANK

Maximum daily demand is = **14,475 m³/day**.
(including the villages of respective taluk)

A general rule is that the capacity of the storage tank should be 20-40 % of the peak day water demand.

Therefore, the capacity of the tank $= 0.2 \times 14475$

$$= \mathbf{2895 m^3/day}$$

Provide a water tank of **2900 m³**, which must be filled 5 times a day.

Capacity of tank required = 2900 m³
The height of tank is assume = 8 m
Free board as = 0.2m
Width of the tank is assumed to be = 15 m
Length of the tank is assumed to be = 25 m

Actual capacity of tank = $b \times d \times h$

$$= 25 \times 15 \times 8$$

$$= \mathbf{3000 m^3}$$

The maximum daily demand for complete taluk is more. Pumping of excess water may lead to extraction of salt water. Hence, the water distribution design mainly done to urban area only.

Total population in the year 2011 = 1,66,264
Population in urban area in the year 2011 = 19,109
From the above data it can be observed that; In the year 2011, 11.49 % of total population is in urban area.
By considering this,

We can assume that, after 40 years i.e., in the year 2051 approximately about 30 % of total population may be live in urban area.

Total population in the year 2051 is forecasted as;

$$P_{2051} = 1{,}93{,}000$$

Now,
The population in urban area in the year 2051

$$= \frac{30}{100} \times 193000$$

$$= \mathbf{57,900}$$

Total demand of water $= 57900 \times 150$

$$= 8685000\ litres$$

$$= 8685\ m^3/day$$

$$= \mathbf{0.101\ m^3/sec}$$

As the considered region is already having a public water supply system, we can consider this system as secondary one.
And therefore, we can consider only 50 % of water demand;

i.e. total demand of water $= \frac{50}{100} \times 8685$

$$= 4342.5\ m^3/day$$

$$= \mathbf{0.05\ m^3/sec}$$

Here as designed above, **3000 m³** capacity tank is only used in this water supply system to store excess water in times of need. Then the tank is needed to fill twice a day to meet the requirements.

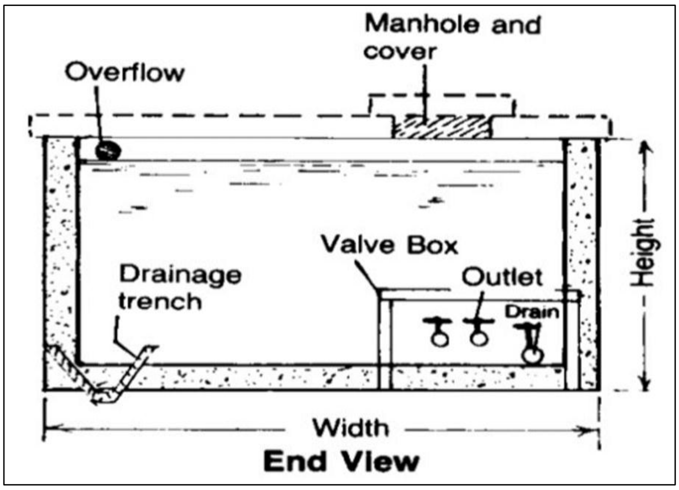


Fig – 9: Design of Storage Tank

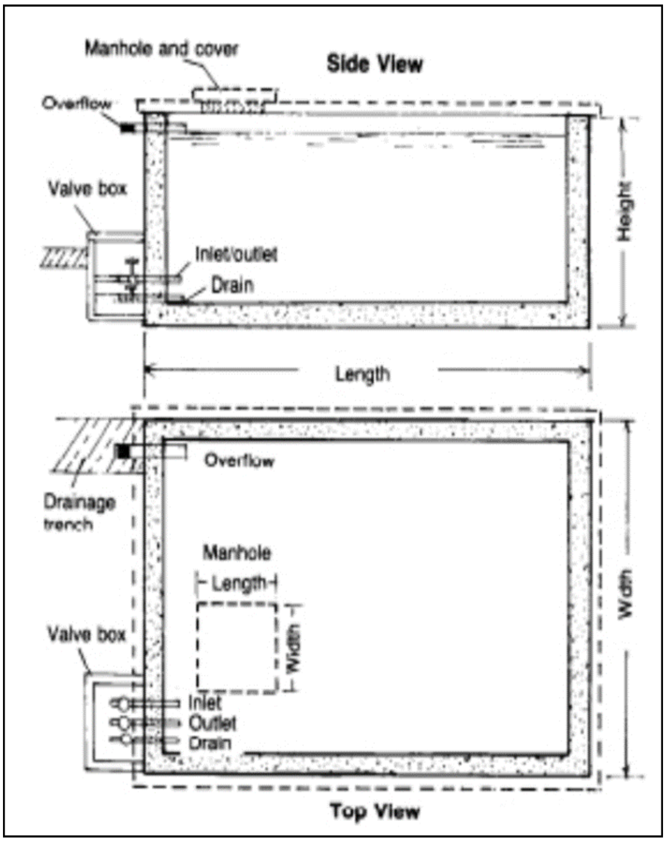


Fig – 10: Design of Storage Tank

6. RESULTS AND DISCUSSION

6.1. WATER TEST ANALYSIS

a. STATION 1

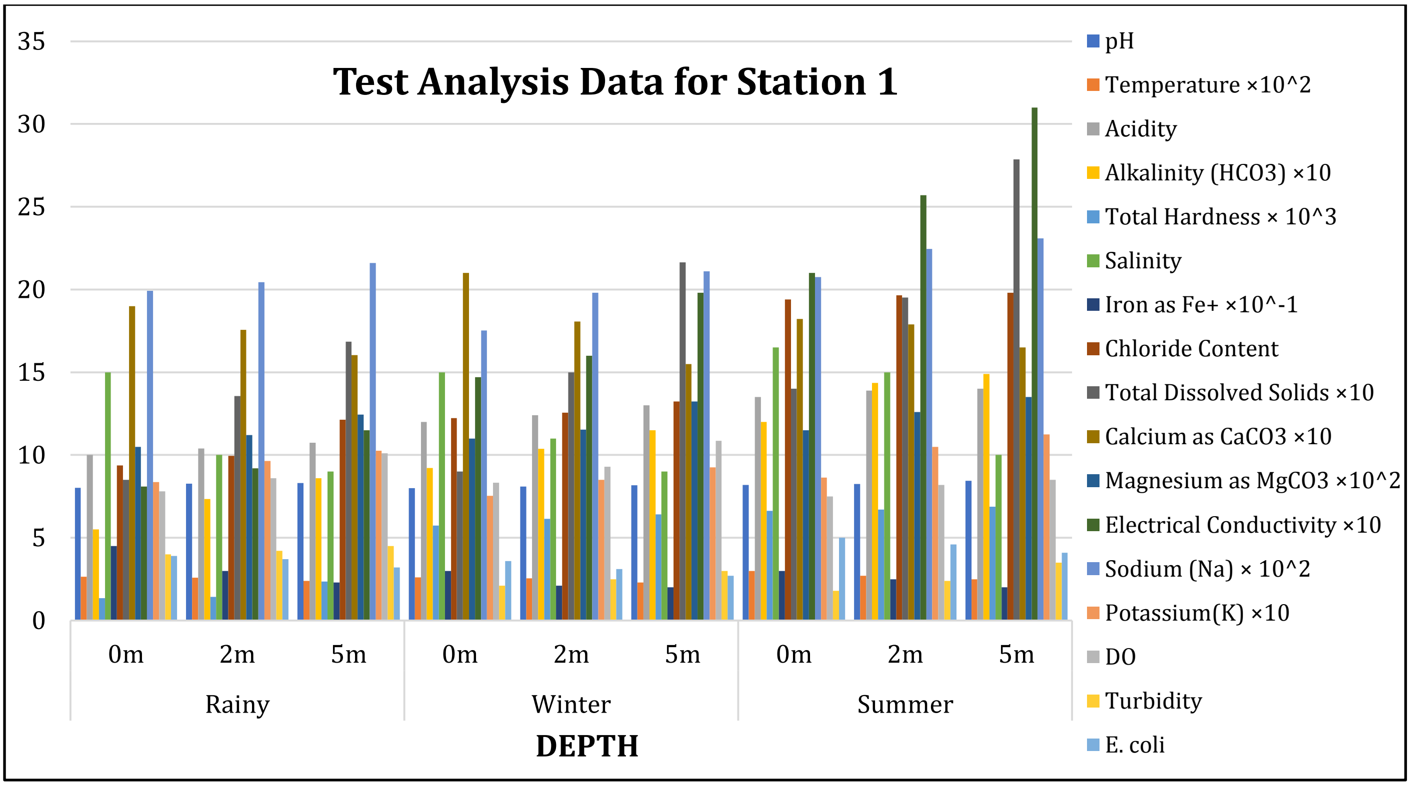


Chart - 1: Test Analysis Data for Station 1

b. STATION 2

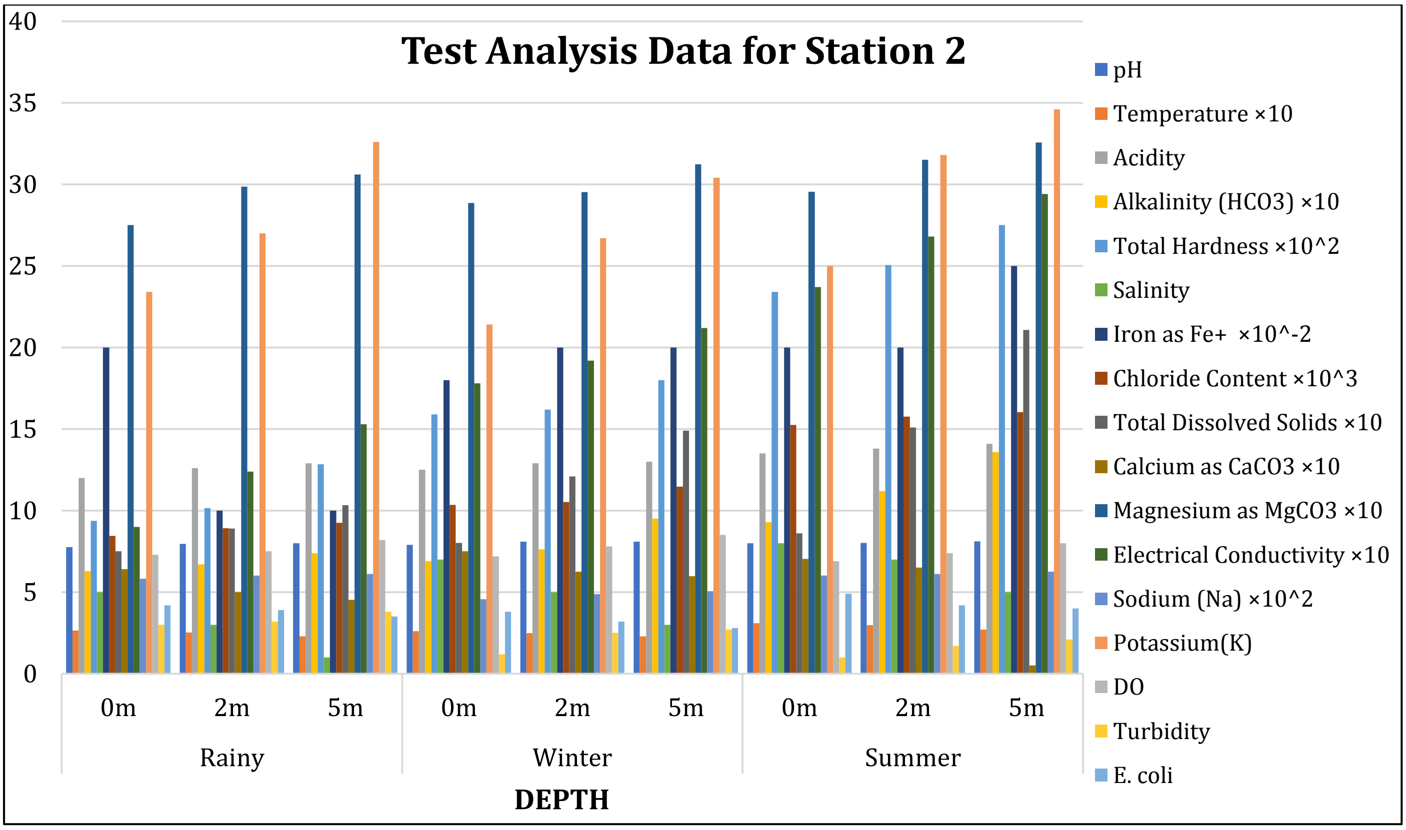


Chart - 2: Test Analysis Data for Station 2

c. STATION 3

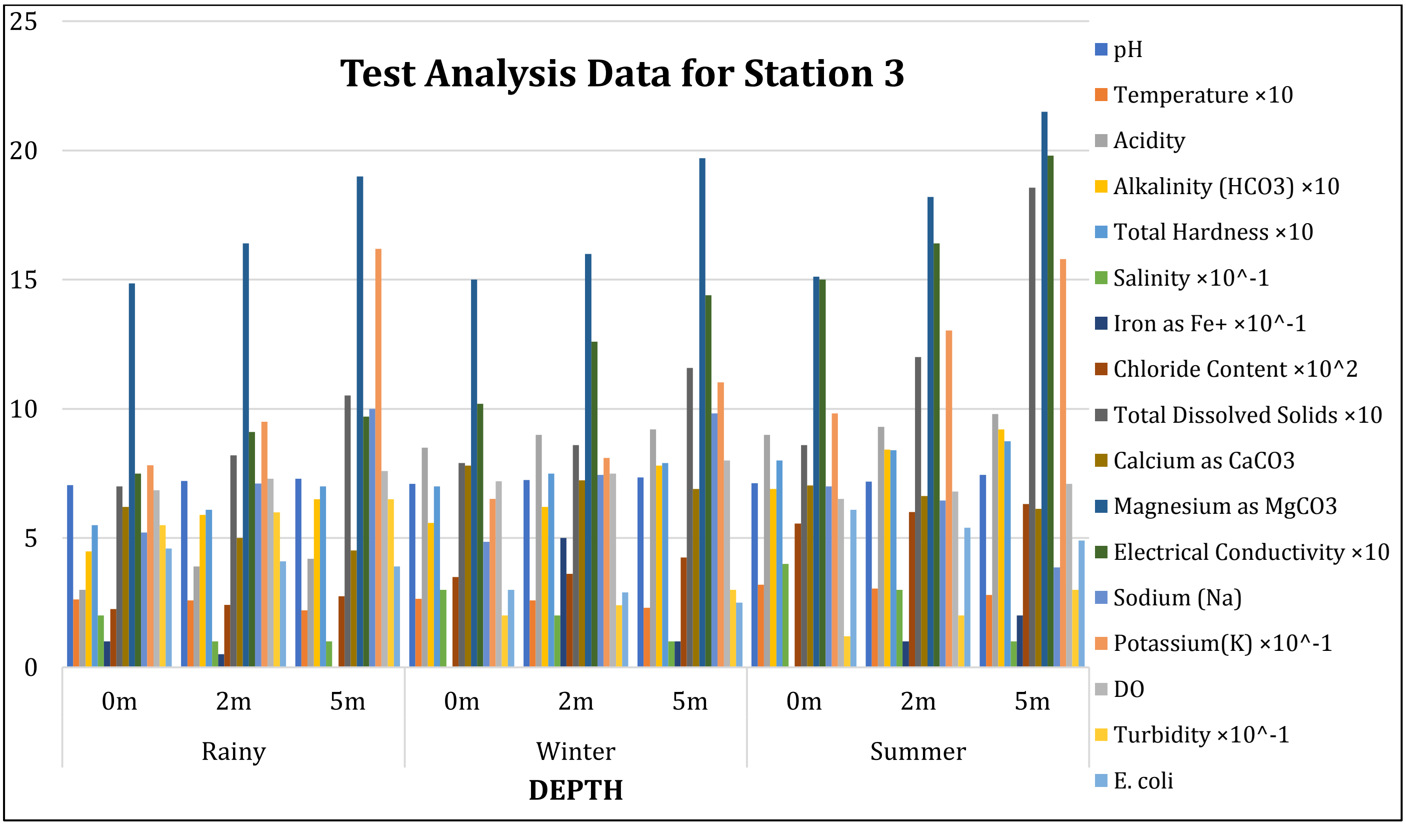


Chart - 3: Test Analysis Data for Station 3

d. STATION 4

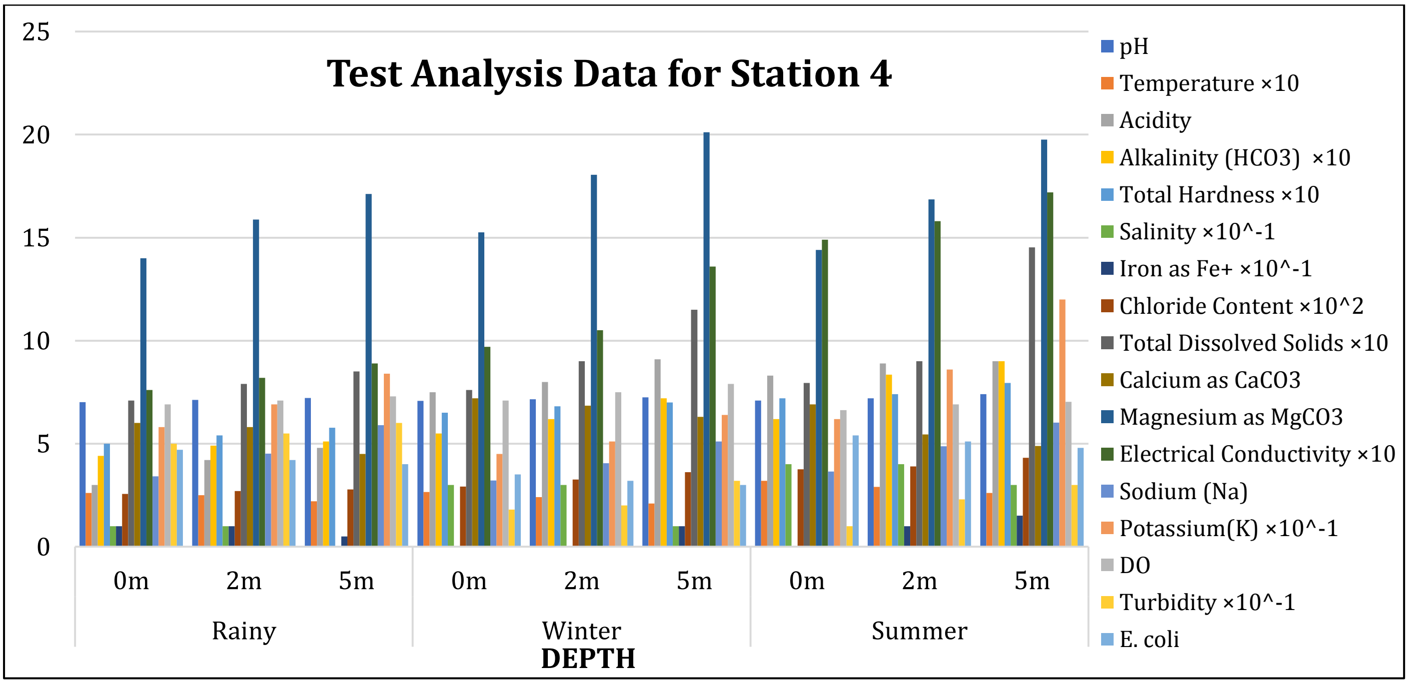


Chart - 3: Test Analysis Data for Station 4

From above obtained graphs and results of selected study area we can conclude that, water flowing through station 4 and station 3 satisfy the permissible limits and condition of all the water test parameters according to BIS 10500 recommendation. Water flowing through station 1 area meets the sea and shows high value for all the parameter of water test which exceeds the permissible limit making itself suitable for generating and conducting electricity form the tides produced in the area.

6.2. TEST AANLYSIS AFTER PURIFICATION PROCESS

Among the 4 station samples tested, water parameters of station 3 and station 4 samples are all in permissible range recommended by BIS. So, the water samples from station 3 and station 4 were purified by simple reverse osmosis process. The purified water was again proceeded to same water test to verify that the water is suitable to place the pump for pumping of freshwater.

a. STATION 3

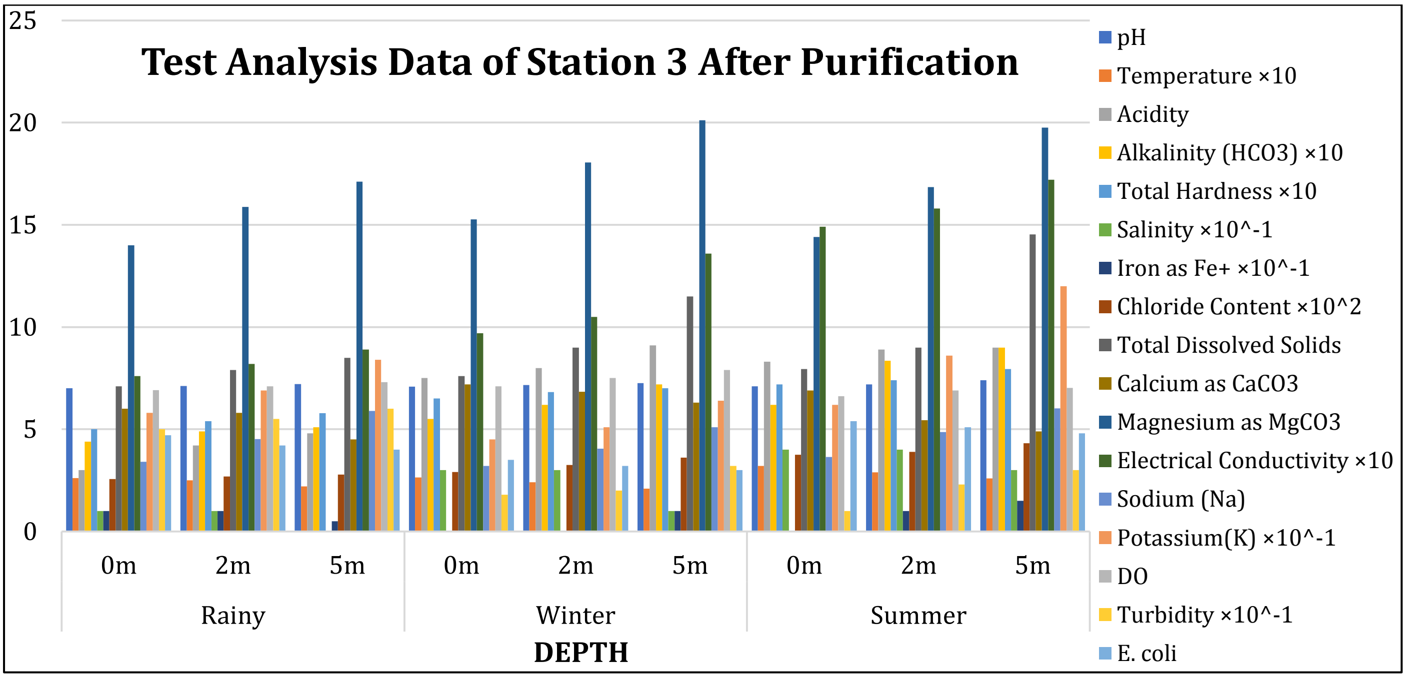


Chart - 5: Test Analysis Data of Station 3 After Purification

b. STATION 4

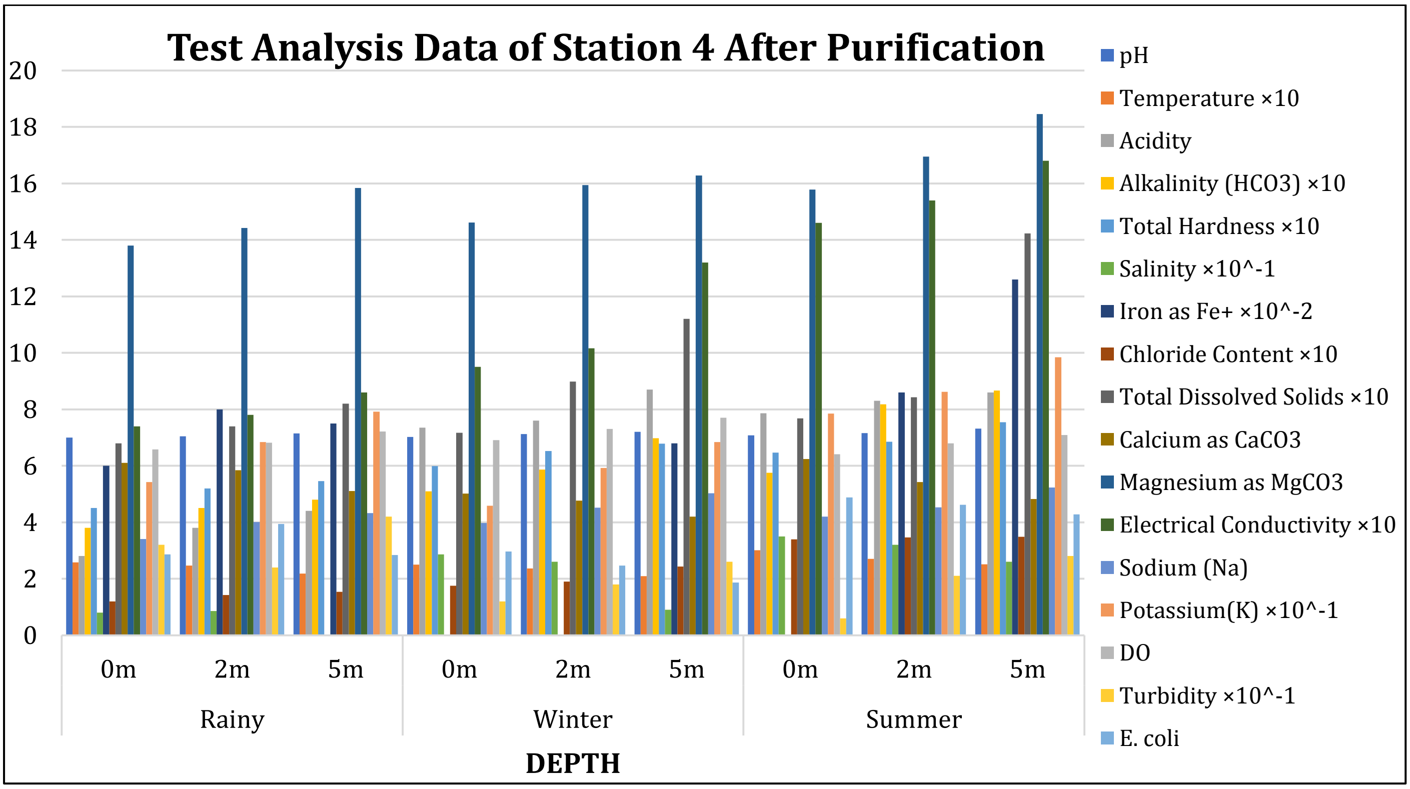


Chart - 6: Test Analysis Data of Station 4 After Purification

As a result, the tested water also satisfies the test parameters according to BIS 10500. Hence, the water is suitable for pumping of freshwater as well as drinking and domestic purposes. Water flowing through station 1 area meets the sea and shows high value for all the parameter of water test which exceeds the permissible limit making itself suitable for generating and conducting electricity form the tides produced in the area

6.3. SOIL TEST ANALYSIS

a. SOIL-WATER TEST

Table- 4: Soil Water Test

Samples Station	1	4
pH	7.4	6
Conductivity (umhos/cm)	2	1.7
Acidity (mg/l)	38	27.5
Alkalinity (mg/l)	530	435
Chloride (mg/l)	160.3	210
TDS (mg/l)	830	655

Table-5: - Results of Specific Gravity of Soil Samples

Particulars	Station 1	Station 4
Wt. Of Pycnometer W1 (g)	680.5	680.5
Wt. of Pycnometer + Dry soil W2 (g)	980.5	991.0
Wt. of Pycnometer + Soil +Water W3 (g)	1754	1760
Wt. of Pycnometer + Water W4 (g)	1566.5	1566.5
Specific Gravity	2.66	2.65

b. SPECIFIC GRAVITY

SPECIMEN CALCULATIONS:

$$\text{Specific Gravity} = \frac{(W_2 - W_1)}{(W_2 - W_1) - (W_3 - W_4)}$$

c. GRAIN SIZE ANALYSIS

Table - 6: Soil Sample at Station 1 Collected in Month of October

Sieve No	Sieve size (mm)	Weight retained on each sieve (gm)	Cumulative weight retained (gm)	Cumulative percentage retained (gm)	Percentage Finer (%)
1	4.75	16	16	1.6	98.4
2	2.36	6.5	22.5	2.25	97.75
3	1.18	5.5	28	2.8	97.2
4	0.6	5.0	33	3.3	96.7
5	0.3	17.5	50.5	5.05	94.95
6	0.15	884	934.5	93.45	6.55
7	0.075	36	970.5	97.05	2.95
8	PAN	29.5	1000	100	0

Table - 7: Soil Sample of Station 4 Collected in Month of October

Sieve No.	Sieve size (mm)	Weight retained on each sieve (gm)	Cumulative weight retained (gm)	Cumulative percentage retained (gm)	Percentage finer (%)
1	4.75	18	18	1.8	98.2
2	2.36	17	35	3.5	96.5
3	1.18	5	40	4.0	96.0
4	0.6	9	49	4.9	95.1
5	0.3	22.5	71.5	7.15	92.85
6	0.15	858	929.5	92.95	7.05
7	0.075	40.5	970	97	3.0
8	PAN	30	1000	100	0

The results obtained from soil test were in permissible range according to BIS 2720 and 1888. Hence the selected area for soil test is suitable for construction.

7. EXPECTED OUTCOME

- Power harnessed by a turbine per rotation is 1MW and using 3T turbine gives 3MW which leads to the generation of excess power than in need. Apart from providing energy to pump water the generated power can provide electricity to millions of houses and also can be stored and introduced to factorial and industrial work.
- During rainy season, the excess water pumped per day can be stored separately for future use. Water pumped can also be used for agriculture, irrigation and other useful purposes apart from drinking and domestic use.
- Since the quantity of extraction of water can be more in quantity, the minerals obtained and separated during the purification process can be further processed and used as fertilizers for soils in agricultural purpose.
- In consonance with this proposed project, borewells can be avoided and restoring of groundwater can be done easily.

8. CONCLUSIONS

Through the results obtained from the tests and designs calculated, theoretical study was made on how power is generated, converted and transmitted to the pump station via marine cables and general electricity cables for pumping process. Designed pipes are connected between the pump and the treatment plant, where general/normal purification of water is being done as the water obtained will be in its purest form, which is further stored and distributed to the town.

The study also includes that Pump will be placed only up to the depth slightly less than the depth of the freshwater so that no saline water can be pumped and the pump will be safe from corrosion. Pumping of water will be done only for certain period of time because excess pumping can harm the water living bodies and also after certain period of time the freshwater will merge in the seawater through tidal waves. Similarly, even the tidal stream generator generates energy for only certain time duration because after certain period of time tidal waves move backward and ebb tides are formed., though it is a continuous process in the ocean. But the energy generated in tidal stream generators are more than sufficient for pumping of water and distribution process. This power generating method can also be converted and stored to produce electricity to the town. The main advantage of this study is borewells can be avoided and restoring of groundwater can be done easily. The study also explains that the proposed project has some favorable distinct features which makes it possible to be sustainable, renewable, eco-friendly and friendly to environment.

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