Water Quality Assesment for Aquaculture at Shasan GP, Barasat-II Block, North 24 Paraganas, West Bengal

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A thesis submitted towards partial fulfilment of the requirements for the degree

of

Master of Engineering in Water Resources and Hydraulic Engineering

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Declaration of Originality & Compliance of Academic Ethics

I hereby declare that this thesis paper contains theory on a literature survey, and original research work by the undersigned candidate, as part of my **Master of Engineering in Water Resources & Hydraulic Engineering** in the Faculty of Interdisciplinary Studies, Jadavpur University during the academic session 2020-22.

All information in this document has been obtained and presented in accordance with academic rules and ethical conduct.

I also declare that, as required by these rules and conduct, I have fully cited and referenced all material and results that are not original to this work.

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Certificate of Recommendation

This is to certify that the thesis entitled "**Water Quality Assesment for Aquaculture at ShasanGP, Barasat-II Block, North 24 Paraganas, West Bengal**." is a bonafide work carried out by **Mr. Subhankar Rajbanshi** under our supervision and guidance for partial fulfilment of the requirement for the Post Graduate Degree of Master of Engineering in Water Resources & Hydraulic Engineering during the academic session 2020-2022.

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This foregoing thesis is hereby approved as a credible study of an engineering subject carried out and presented in a manner satisfactorily to warranty its acceptance as a prerequisite to the degree for which it has been submitted. It is understood that by this approval the undersigned do not endorse or approve any statement made or opinion expressed or conclusion drawn therein but approve the thesis only for purpose for which it has been submitted.

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ABSTRACT

Mangrove ecosystem being suitable for brackish water shrimp culture, large number of aquaculture ponds have been developed in Shasan area,Barasat block-II, North 24 Parganas, West Bengal, India. These ponds are regularly fed by brackish water from nearby Bidhyadhari river system and the same water is ultimately discharged into this aquacultural ponds. In the present study, some physico-chemical parameters such as pH, temperature, conductivity, dissolved oxygen, calcium, magnesium, total hardness, chlorine, phosphate, nitrate, and total dissolved solid contents of four aquaculture ponds have been analysed for assessment of pollution status with respect to canal water taken as control. Studies were undertaken for a period of from May 2022 to June 2022 (pre-monsoon season) during which the physico-chemical parameters were compared with the water quality standard of Bureau of Indian Standard (BIS) and Central and the State Pollution Control Board (PCB) and Aquaculture guidelines as per CIFA. The BOD values of the aquaculture ponds range between 13 -73mg/L as against the value of standard water quality. Nitrate, total hardness, calcium, magnesium, phosphate, and chlorine contents show variation within different sites. Ammonia concentration values vary from 11.0 to 26.0 mg/L during investigation, which is higher than standard value. Among these sites, Kholdanga ponds show the excessive values in respect of some parameters than other site. The water quality index WQI also met the criteria for aquatic species except Kholdanga pond. In weighted arithmetic index method, two ponds i.e. Kholdanga and Pranab pukur unsuitable for aquaculture and in respect of DOE index method, Kholdanga unsuitable for aquculture. Its require some treatment as soon as possible.

Key Words:- Aquaculture, WQI, Arc GIS, Parameters, AWI index, DOE Index

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Chapter -1

Introduction

1.1 General Background:-

Water is a very important substance of the environment to sustain life on the earth. It is in liquid form at normal temperature (0^{O}C to 100^{O}C) and solid-state as ice glacier in polar region and cloud, water vapour as a gaseous state (Deepika et al.,2020). About 96.50% of water in oceans is saline water, 1.0% is around others forms of saline water, and 2.50% of water is freshwater (U.S. Dept.). Around 1.2% of these freshwaters as surface water. West Bengal is a riverstic state. Almost hundreds of rivers and numerous lakes are found in West Bengal. Ganga, Hooghly, Damodar, Teesta, Mahananda, Subarnarekha, Ajay, Churni, Kangsabati, Raidak, Jamuna are most influence river in West Bengal. There are several lakes which directly or indirectly feed by river, canal, reservoir etc. These canals, rivers reservoir is the main water sources for aquaculture.

Now a day's Shrimp farming as well as aquaculture is very profitable business other than agriculture and animal husbandry, like Poultry, Dairy. In India, it plays an important role of generating Foreign exchange and employment (Kumar, 1997). Majority of shrimp farms in India are completely export oriented purpose. Out of a total 1.456 million hectare of brackish water area available in India, 0.902 million hectares are being utilized especially for shrimp farms (Mishra et al, 2008). In India, Fisheries/ Aquaculture sector contribute 1.24% of Indian Economy and 7.28% contribution in Agriculture sector of India in 2018-2019. Total inland fish production 10.43 MMT and total quantity of Fisheries export 12,89,651 tons in 2019-2020 (Hand Book on Fisheries Statistics,2020). Scientific culture of shrimp started in West Bengal, India during the mid-1980s and by 2010 more than 47,588 ha area was brought under shrimp culture. The development of coastal aquaculture in West Bengal was centred on Peneaus monodon farming until 2015. By 2015, the area under shrimp culture rose to 53,974 ha (MPEDA, 2015) and by 2021, the area under shrimp culture rose to 56,059 ha (MPEDA, 2021). The current aquaculture production of shrimp in West Bengal increased from 26,800 tons in 2001-2002 to 57369.77 tons in 2014-2015 (MPEDA, 2015).

In West Bengal or all over India, Aquaculture is one of the major sectors for human beings and around 1.07% of the country's Gross Domestic Products (GDP) (PIB). It is the important source of livelihood of about 145 million people of India directly connected with aquaculture. Aquaculture in West Bengal is mostly dependent on Surface water canal feed by Perennial River or canal (Dept. agriculture). Many ancient civilizations developed on the freshwater river banks and fishing play very important role in their life, but in current situations rivers, lakes, ponds i.e. surface water as well as groundwater affected greatly due to rapid urbanization, industrialization, and other human activities. In presents day the water characteristic does not match the Irrigation requirement as well as aquaculture fully due to contamination of chemical elements etc. Pollutants are released into the water which affects the environment and human life and all most biosphere. Water quality continuously deteriorates as it flows from a different place. There are too many problems that arise in the aquatic ecological system as well as whole bio-diversities (Deepika et al.,2020).

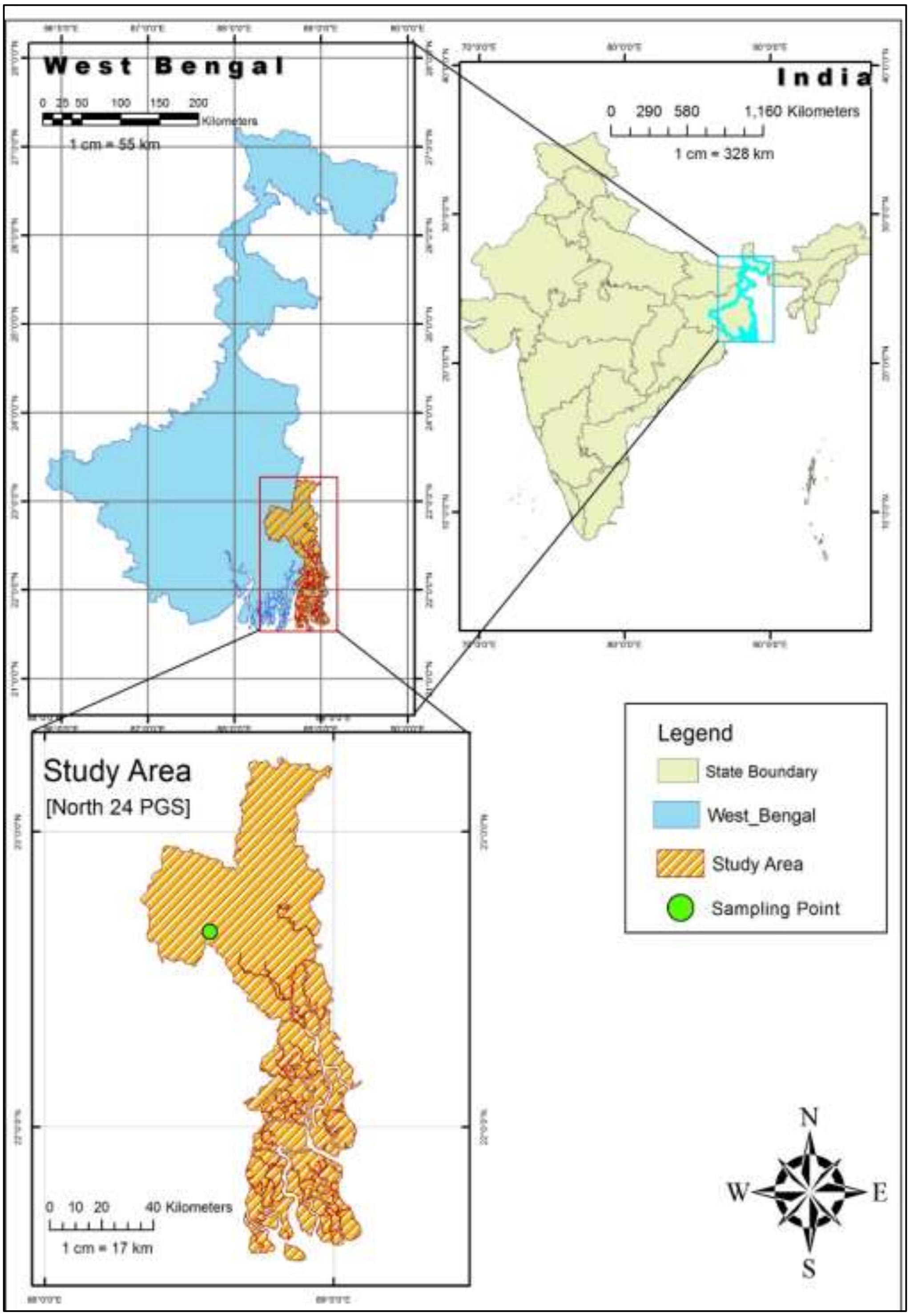
Additional impurities are added to the water when it comes into contact with materials. Human activities contribute further impurities in the form of industrial waste, chemical waste, agricultural waste, and domestic waste. Water is called Polluted when the presence of impurities in such quantities and nature makes the water inappropriate for a specific purpose. The quality of water is predicted based on the gross determination of the quantity of suspended and dissolved impurities. Many parameters are involved to reflect the quality of water and identify the ways that the water is to be used. Some analytical procedure has been developed and some standard methods involve for examination of water (Deepika et al.,2020). Knowledge of the parameters of the water and wastewater treatment process is essential for environmental engineers. These parameters are used to assess the physical, chemical, and biological characteristics of water.

1.2 Objectives:-

The main objective of research study is to assessment of water quality scenario of the pond and the canal water used for aquaculture. Qualitative analysis of large water bodies (Specially Aquacultural Pond) used for Aquaculture in West Bengal. Analyse water sample from different place of selected areas and Identifying the obstacle for production growth of aquaculture, related to water quality.

1.3 Study area:-

The study area is between Shasan and Kharibari under Barasat block-II, North 24 parganas, West Bengal, India located at 22°39’46”N & 88°34’17”E. The detail information about the study area is given in chapter 3.



Map 1: Study Area

Map 2: Sapling Area

1.4 Thesis outline: -

The thesis is divided into seven chapters. Second chapter offers a review of the literature; third chapter gives information about Study area; Fourth chapter give overview about the water quality parameters; Fifth chapter introduce the research technique and methods. The data analysis and results are presented in sixth chapter and finally, the summary of the research study is presented in seventh Chapter in the form of conclusions, discussion, and recommendations, as well as the future scope of the study. The dissertation concludes with a list of references.

Chapter -2

Literature Review

2.1 National and International Literature Review: -

Dasgupta.S et al., (2007), Reuse of wastewater in aquaculture, enhance water productivity of the system. Quantification of nutrient inputs incorporated through treated domestic sewage with varying dosages viz. 79.3 x 105 l /ha and 67.7 x 105 l/ha. In a controlled carp culture system, water productivity was assessed in comparison to those involved in a fertilized based one, with a view to correlate among physical, chemical and biological processes involved in fish yield under the systems. Selected relevant water parameters such as dissolved oxygen, total alkalinity, biochemical oxygen demand (BOD_5) in sewage effluent and fertilizer based systems were monitored along with certain biological parameters viz. gross primary productivity, fish production and water productivity. The nutrient inputs in terms of total ammonia–nitrogen (TAN) in effluents, total nitrogen (TN) in fertilizers and phosphorus (P_2O_5) in both effluents and fertilizers were found significantly correlated with biological production. The results of the experiment found that sewage incorporation at 79.3 $x10^5$ l/ha yielded similar gross fish production as recorded from fertilizer based system, whereas net water productivity using sewage as nutrient source was found 64% higher than that of a fertilizer based system.

F.S. Simo˜eset al., (2008), This paper proposes a water quality index (WQI) to subsidize management actions in the Me´ dio Paranapanema Watershed in Sa˜ o Paulo State, Brazil. It is a simple pollution indicator for aquaculture activity. Water quality of the Macuco and Queixada rivers was investigated for 2 years (2003 to 2005). Three parameters are used to build these index i.e. turbidity, total phosphorus and dissolved oxygen. Based on the Concentrations of these three variables were normalized on a scale from 0 to 100 and translated into statements of water quality (excellent, good, regular, fair and poor). This index was applied to seventeen monitoring points in the aquatic bodies one being that used by the Environmental Protection Agency of United States and proposed for the National Sanitation Foundation, other employing minimal index and the minimum operator concept. It's denoted that WQI_{min} may be used as a new tool for hydrographic watershed management and can be employed in the aquatic body monitoring.

R. R. Mishra et.al., (2008). Research on water quality leads to aquaculture in area of 'Bhitarkanika'. There are several ponds (aquaculture ponds) which directly fed from 'Brahamani-Baitarani' river systems situated in Orissa, selected seven different places. Used MSTAT-C statistical software for month wise variation of these sites of each parameter compared by using ANOVA with significant level ($P \leq 0.5$). After experiment and laboratory test, it concludes the pH level of water of these samples varied from 5.63 to 8.5; it means that water of some place is acidic. It may be due to chemical additives applied to the pond for better production. It shows high conductivity denotes high organic residue presents in the water may be due to temperature variation affects the organic degradation. High dissolve oxygen presents in some ponds which indicate better life for aquatic species while it may be used Chemical generate dissolve oxygen like Calcium Peroxide, Oxyflow as well as mechanical aerators used for better production of shrimp. The calcium and magnesium present in water is different in different sites represents lime and pesticides applying in the water and ponds which directly connect through river channel show salty water.

K.K.Sharma et al., (2013) works on the consumptive water use for freshwater pond aquaculture for semi-intensive carps farming practices. Consumptive use of water includes evaporation loss, seepage loss and water exchanges requirements. The water requirement has been estimated to be 10.3 m^3/Kg of fish production under present study for semi-intensive culture and with supplemental feeding. Out of which 7.6 m^3/Kg of fish production is system associated requirement. Average the evaporation loss from the pond is 1498.3 mm/year and seepage loss per year is about 1182.60 mm/year. Seepage and water exchange losses recharge the ground water aquifers, the water use in aquaculture can be reduced significantly.

N.C. Ezeanya et al., (2015). Works on standard water quality requirements and management strategies suitable for fish farming. Water samples collected from Otamiri River in Imo state, Nigeria, were analyzed based on the afore-mentioned criteria to assess its suitability for fish farming. Results of the research work compared with international standards and found that river temperature, nitrate-nitrogen, total suspended solids within acceptable range but pH, total hardness, total dissolved solids, and biochemical oxygen demand differ from the standard recommended values.

A. Hussan et al., (2016). Wastewater treatment using waste stabilization ponds is very efficient and inexpensive but the main barrier that it's require large area. This study was undertaken to assess the effect of diluted waste water on histology of gills. The results showed severe pathological alterations in gills of Rohu (Labeo rohita) up to 1: 6 dilution and changes were less at dilution 1:8 and above. In urban areas, where both land and availability of large pond is major problem, another option is chemical treatment. Chemical oxygen demand (COD) and Phosphorus (PO_4) from waste water was removed by chemical precipitation using zeolite, alum (Aluminium sulphate) and their combinations. It was observed that alum and zeolite absorb phosphorus 85% and 78% respectively and remove COD 67% and 57% respectively. But zeolite-alum mixture removes phosphorus (85%) and COD (68%) at much lower dose and also helps in balancing the pH. The results of this study denoted probability of using diluted wastewater for fish culture, as an increase of dilution factor significantly reduced the pathology on fish gills.

R. K. Mohanty et.al., (2018). Research on water quality assessment for aquaculture in 'Balasore' district, Odisha from 2015 to 2017 based on stocking density and Water quality suitability index (WQSI). Three Types of crops are taken for experimental basis. Duration of each crops about 120 days' size of each pond 5000 sq.m. Author used the Generalized Linear Model (GLM) for data analysis using SAS 9.2 (SAS Institute, 2002). Two multiple comparison tests, namely Duncan's Multiple Range Test (DMRT) and Tukey's test were employed to assess the differences among the treatment means at the 5% significance level (i.e., $p < 0.05$). The recorded minimum and maximum range of average total alkalinity was101 ppm to 123 ppm under different stocking density treatments. Lesser shrimp biomass at low density resulted in higher WQSI. A good rating of WQSI (5.5–7.5) was recorded in all treatments represent moderate management required. During the experimental period, the composition of sand, silt, and clay was 31.3%, 19.9%, and 48.8%, respectively. Organic carbon (%), available N and P in soil (mg/ 100 g) varied between 0.38–0.46, 11.6–13.8 and 1.22–1.38, respectively at the beginning of the experiment. The estimated evaporation and seepage loss ranged between 0.54–0.66 and0.46–0.56 m^3 water kg^{-1} shrimp production, respectively during the crop cycles.

Abraham et al., (2019). Works on the investigation of the physicochemical characteristics, management practices, distribution of vibrios, and the prevalence of bacterial, parasitic, and viral diseases in 14 P. vannamei intensive culture farms in the Indian Sunderbans in the year of 2016. Out of these farms surveyed, only 1farm sample was white spot virus (WSV) positive. All the P. vannamei farms were negative for infectious hypodermal and haematopoietic necrosis virus, hepatopancreatic parvo-like virus, and infectious myonecrosis virus. No incidence of Enterocytozoon hepatopenaei, white faecal syndrome, running mortality syndrome, protozoan infestation, and luminous vibriosis was observed during the survey period. The survival rate recorded 90-95% in the normal ponds, whereas 60% in an asymptomatic WSV infected farm. The physicochemical characteristics of the farms were well within the optimum limit, except for the WSV infected farm, which had found high ammonia levels. Due to the lack of awareness on the P. vannamei farming practices and high operational costs, the bio security measures were not strictly followed in the surveyed farms.

S Adhikari et al., (2020). The salinity tolerance level of Indian major carp, Catla catla, Labeo rohita (Jayanti rohu) and Cirrhinus mrigala were ascertained in terms of weight gain and mortality by exposing the fishes gradually to different levels of salinities for 45 days. As per analysis, the severity of impact of increasing salinity was significantly higher ($P<0.05$) in Catla as compared to Jayanti rohu and Mrigal. In case of Catla significant decrease ($P<0.05$) in weight gain was noted from 1 ppt onwards, whereas in case of L. rohita the decrease in weight gain was found significant ($P<0.05$) from 3 ppt onwards and in case of C. mrigala the growth retardation was noticed from 4 ppt onwards compared to control. In case of Catla, mortality started at salinity above 5 ppt, and reached to 100% at salinity level of 8 ppt, whereas, Jayanti rohu showed no mortality up to 6 ppt salinity, though the survivability got reduced to 40% in salinity of 8 ppt. Interestingly, in case of Mrigal no mortality was recorded at salinity level up to 8 ppt on 30 days' post experiment. The result obtained in the present study had given an account of the level of salinity tolerance in Indian major carps.

N. K. Egun et al., (2022). Dealt on the study examined the Ikpoba Reservoir water quality suitability as source water for aquaculture. Sixteen water physico-chemical parameters were monitored for duration of 18 months from February 2018 to July 2019. Results showed that mean water temperature, electrical conductivity, chloride, potassium, calcium, magnesium values were in favour of aquaculture while, mean water pH, turbidity, total suspended solids, dissolved oxygen, biochemical oxygen demand, nitrate and ammonium, iron, copper and zinc concentrations were unsatisfactory for the breeding and survival of fish. The levels of unsatisfactory physico-chemical parameters and their effects on the development of fishes make the reservoir water unsuitable for use in freshwater aquaculture.

Chapter -3

Description of study area

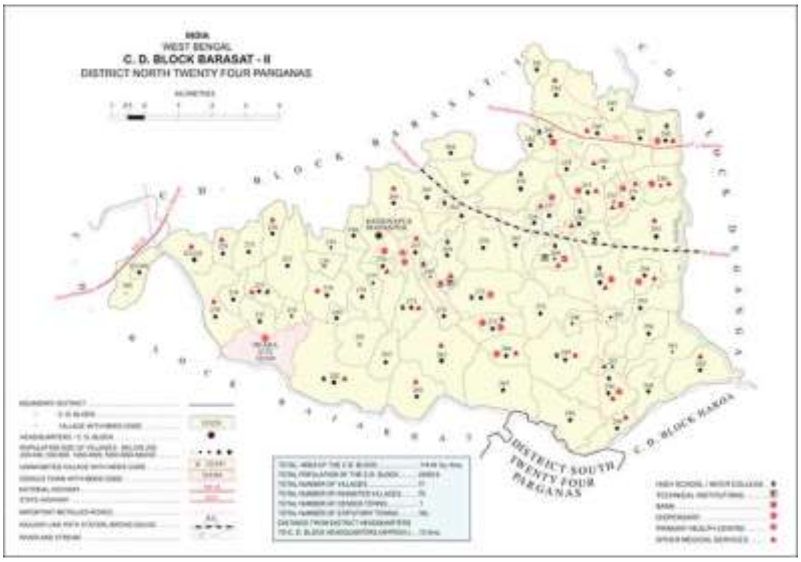
3.1 Introduction:

The study area situated in Barasat Block-II, which bouded by Barasat –I at north, Deganga and Haroa at west and Rajarhat CD block at the south. The study area was carried out in Chaumuha, Mudia, Bardeshia, Khamar Noabad, Shasan and Kharibari area under Barasat-II block, North 24 parganas, West Bengal, India located at $22^{o}39'46''$ N & $88^{o}34'17''$ E. The area of each pond varies from 2ha to 10 ha which feed directly from the canal by lock-gate or pump or concrete pipe. These sites are selected on the basis of location, man-made or natural sources of pollution, nearest location of canal starting and end point of these ponds.

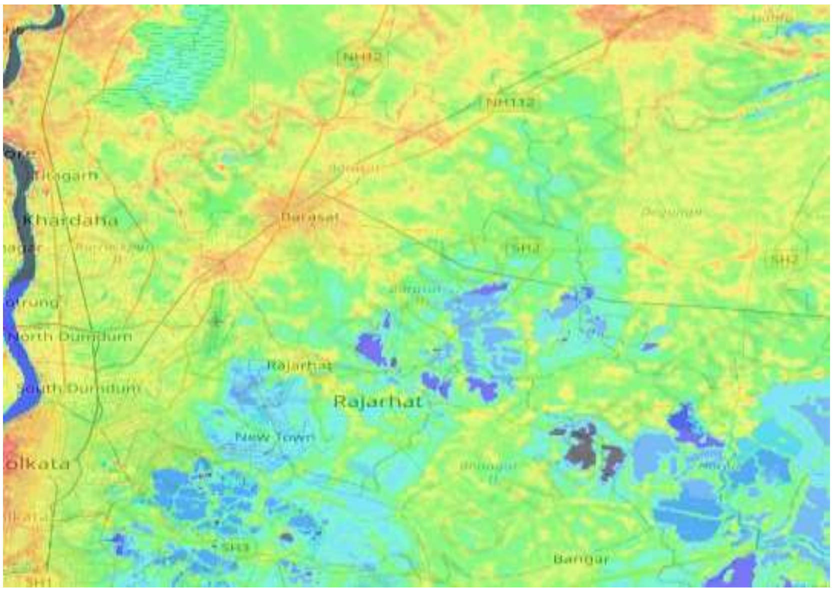
Map 3: North 24 Parganas Administrative Area;
Source: WB Govt. site

3.2 Geographic Profile:

This area generally low land almost plane region consist of 70 to 80 aquaculture ponds beside canals of Bidyadhari River. This canal also known as Haroa khal. It is one of the natural tributaries of the river Bidyadhari. The Area consists with Alluvium soil of Ganges Delta and partly with north Bidhydhari plain. Barasat block-II has an area about 114.04 Sq.km and the water bodies' boundary of the study area near about 33km and area about 3434 ha. The water bodies cover most of the part of the block. Most of the part of this block is rural area. The total population of the block is 2,00,918 of which 1,88,294 were rural and 11,994 were urban as per census of India 2011.



Map 4: Barasat Block-II Administrative Area;
Source: N24pgs govt. site



Map 5: Topograhical map of Barasat Block-II.
Source: Esri topograghy map.

3.3 Economic Profile:

As per census of India 2001, 23.11% of household in Barasat block-II lived below poverty line whereas on an average 29.28% in North 24 parganas. This block account 13.73% of the total population is cultivators, 26.80% are agricultural labours, and 3.96% are household industry workers and rest are other workers as per census 2011. Majority of the population (1,34,779 person) are non-workers and 65,223 persons are illiterate (Census 2011). Aman, Boro Paddy, wheat, Jute, Potatoes, and some oilseeds are the major agricultural product produces in the block. The most important around 2,752.76 ha and 15,874 persons were directly involved in the profession of Pisciculture as well as aquaculture. Annual production was approximate 8,258.28 tonnes recorded in 2010-11.

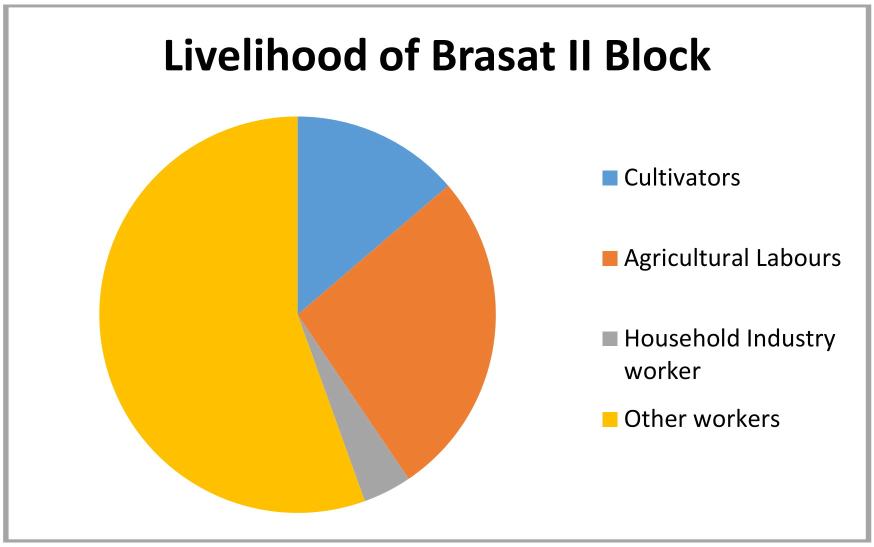


Chart 1: Perspective view of economical condition of the Study area

3.4 Existing scenario:

The study area is topographically of lower elevation. The western part of this block is higher comparatively eastern part. It's one type of bowel shape area. In general water collected from western and northern part. The average elevation found 5m and the minimum elevation -2m (source: Esri topo map). In rainy season, the water level increase about 1.5m. Ponds are flooded due to heavy rain, fishes are flowing with water as no boundary exists and cultivators get losses. Some fish thieves stolen fish due to lack of supervision. Rohu, Catla, Mrigel, Grass carp and Prawn (L. vinnamei, P.monodon) were farming widely in this ponds. But last few years, Prawn farming continuously decreasing due to dieses. It's may be due to unscientifically application of different chemicals and not properly maintain of water quality. As per survey, it is noticed that some people are very carless about water quality management. They only focused on the high growth fertiliser, food grains etc.

Fig. A: Existing Site photograph of Haroa canal outlet

Fig. B: Existing Site photograph of Pranab pukur.

Fig. C: Existing Site photograph of Kharibari area.

CHAPTER-4

Water Quality Parameters

4 Water quality parameters: -

Water quality parameters are classified as physical parameters, chemical parameters, and bacteriological quality parameters.

4.1 Physical Parameters: -

Physical parameters are those characteristics that respond to the senses of sight, touch, smell, taste, odor, color, suspended solids, temperature, etc.

4.1.1 Suspended solids: -

The term suspended solids (SS) refers to the mass (mg) or concentration (mg L^{-1}) of inorganic and organic matter or immiscible liquid, which is held in the water column of a stream, river, lakes, reservoir, etc (G.S.Bilotta et al., 2008). SS is typically comprised of fine particulate matter with a diameter < 62μm and all streams carry some SS under natural conditions (P.A. Ryan et al., 1991). Some organic materials such as plant fiber and biological solids are common constituents of surface water. Domestic wastewater contains a large amount of Suspended solid of organic nature and Industrial wastewater having wide verities of suspended impurities.

Suspended solids can clog fish gills and reduce their growth rate rapidly. It also reduced light penetration in the sample. It reduces the ability of algae to produce food and oxygen. When water flows slowly and enters a reservoir, the suspended sediment settled down at the bottom (siltation). The positive effect of SS in water, toxic chemicals such as pesticides and metals tend to adsorb to them or become complexes with them, it makes the water toxics less (Total SS).

There are several methods to determine suspended solids most are gravimetric tests by measuring TS. A well-mixed sample is filtered through a pre-weighed glass filter and the filter is then dried in a drying oven and reweighed the sample. The weight gain represents the TSS and is expressed in mg/L (WQP). Most SS can be removed by filtration and the number of dissolved solids, passing through the filter (expressed in mg/L) is the difference between TS and SS of the water sample.

4.1.2 Turbidity: -

Turbidity is a measure of the extent to which light is either absorbed or scattered by suspended material in water and it is to be noted that turbidity is not a direct quantitative measurement of suspended solids. Most turbidity in surface waters results from the erosion of colloidal material such as clay, silt, rock fragments, and metal oxides, etc. Detergents, soaps produce stable colloids, which results in colloids.

Water in natural bodies' turbidity may impart a brown, depending on the light-absorbing properties of solids. It may interfere with light penetration. Turbidity is measured photometrically by determining the percentage of light absorbed or scattered of specific intensity. Jackson turbidimeter with a unit of JTU (Jackson turbidity unit) is widely used to measure turbidity. Another unit, NTU (nephelometry turbidity unit) is widely used in the present day (Howard et al.,2017).

4.1.3 Colour: -

Pure water is colour less, when it notices some colour present in water then it’s clear that some impurities are mixed with water. Colour is contributed by dissolved solids. Some organic matter like wood, weeds, leaves presents in water contributes yellowish-brown and industrial waste from textile mills, paper mills, chemical industries, food processing industries, having different oxides (iron oxides, magnesium oxides) turns water reddish, brownish, blackish, etc (Howard et al.,2017).

There are several methods to measure colour in the water, generally used true colour units (TCU). Although it is not affected too much in the analysis of wastewater but also an important factor for potable water analysis (Arnold et al., 1992).

4.1.4 Taste and odor: -

Difference people in their ability to sense tastes and odors describe identical sensations in different ways. While odors also affect our taste perceptions. This causes us to frequently describe tastes in terms of an associated odor. The tongue is only capable of perceiving four flavors: salty, sweet, sour, and bitter (Water.)
Minerals, metals, and salts from soil from biological reactions, and inorganic substances are more likely to produce unaccompanied by taste and odor. Alkaline material imparts a better taste to water.
Direct measurement of materials that produce taste and odor by some known agents and due to organics material by using liquid or gas chromatography. Threshold odor number (TON) test conduct for odor. A maximum TON of 3 has been recommended by Public Health Services (D.water).

4.1.5 Temperature: -

It is the most important parameter in natural water systems. It represents the large extent of the biological species present in water. It also affects the solubility of gases in water. Generally, the shallow bodies of water are more effective by ambient temperature than deeper ones. The reaction rate and solubility level of chemicals are affected by temperature. The viscosity of water increase with the decrease of temperature.

4.2 Chemical water quality parameter: -

As per many thesis and authors, water is recommended as the universal solvent. Total dissolved solids, alkalinity, hardness, fluorides, metals, organics are the chemical parameters.

4.2.1 Total Dissolved solid: -

Solids occur in water either in solution or suspension and these two types of solids can be identified by using a glass fibre filter that the water sample passes through. By definition, the suspended solids are retained on the top of the filter and the dissolved solids pass through the filter. If the filtered portion of the water sample is placed in a small dish and then evaporated, the solids as a residue called total dissolved solids or TDS (Nayla el at.,2019**)**.

Water can be classified by the amount of TDS per litre as follows.
Freshwater: <1500 mg/L; brackish water: 1500–5000 mg/L; saline water: >5000 mg/L.

Total solids (mg/L) =[(TSA–TSB)] ×1000/sample(mL).
Where TSA = weight of dried residue + dish in milligrams and TSB = weight of dish in milligrams.
Total dissolved solids (mg/L) =[(TDSA–TDSB)] ×1000/sample(mL). Where TDSA = weight of dried residue + dish in milligrams and TDSB = weight of dish in milligrams.
Total suspended solids (mg/L) = [(TSSA–TSSB)] ×1000/sample(mL). Where TSSA = weight of dish and filter paper + dried residue and TSSB = weight of dish and filter paper in milligram.

4.2.2 Electrical conductivity (EC): -

The electrical conductivity (EC) of water is a measure of the ability of a solution to carry or conduct an electrical current. Since the electrical current is carried by ions in solution, the conductivity increases and decrease as the concentration of ions increases or decrease. It is one of the main parameters used to determine the suitability of water for firefighting and irrigation. Typical conductivity for drinking water: 0.005–0.05 S/m (Drinking);

4.2.3 pH: -

pH is one of the most important parameters of water quality, defined as the negative logarithm of the hydrogen ion concentration. It is a dimensionless number indicating the strength of an acidic or a basic solution. Acidic water contains extra hydrogen ions (H+) and basic water contains extra hydroxyl (OH−) ions. pH ranges from 0 to 14, with 7 being neutral (Nayla el at.,2019**)**.

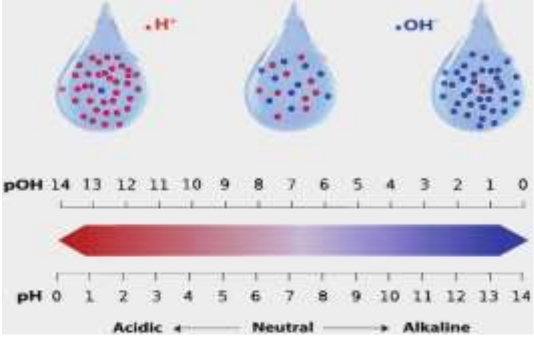


Fig.1: pH of water

pH of less than 7 indicates acidity, whereas a pH of greater than 7 indicates a base solution. Pure water is neutral; with a pH close to 7.0 at 25^{O}C. Normal rainfall has a pH of approximately 5.6 (slightly acidic) owing to atmospheric carbon dioxide. Safe ranges of pH for drinking water are from 6.5 to 8.5 for domestic use and living organisms need (Drinking).

4.2.4 Acidity: -

Acidity is the measure of acids in a solution. The acidity of water is its quantitative capacity to neutralize a strong base to a selected pH level. Acidity in water is usually due to carbon dioxide, mineral acids, and hydrolyzed salts such as ferric and aluminum sulfates. Acids can influence many processes such as corrosion, chemical reactions and biological activities. Acidity level is determined by titration with standard sodium hydroxide (0.02 N) using phenolphthalein as an indicator (Nayla el at.,2019**)**.

4.2.5 Alkalinity: -

The alkalinity of water is its acid-neutralizing capacity comprised of the total of all titratable bases. The measurement of alkalinity of water is necessary to determine the amount of lime and soda needed for water softening. Alkalinity of water is mainly caused by the presence of hydroxide ions (OH^-), bicarbonate ions (HCO^{3-}), and carbonate ions (CO_3^{2-}), or a mixture of two of these ions in water. Alkalinity is determined by titration with a standard acid solution (H_2SO_4 of 0.02 (N)) using selective indicators (methyl orange or phenolphthalein) (Drinking). The acidity and alkalinity in natural waters provide a buffering action that protects fish and other aquatic organisms from sudden changes in pH (Nayla el at.,2019**)**.

4.2.6 Chloride: -

Chloride occurs naturally in groundwater, streams, and lakes, but the presence of relatively high chloride concentration in freshwater (≥250 mg/L) may indicate wastewater pollution. Chlorides may enter surface water from several sources including chloride-containing rock, agricultural runoff, and wastewater.

Standards for public drinking water require chloride levels that do not exceed 250 mg/L. There are many methods to measure the chloride concentration in water, normaly used the titration method by silver nitrate ($AgNO_3$) (Nayla el at.,2019**)**.

4.2.7 Chlorine residual: -

Chlorine (Cl_2) does not occur naturally in water but is added to water and wastewater for disinfection purpose. In drinking water, a residual chlorine 0.2 mg/L is optimal. The residual concentration which is maintained in the water distribution system ensures good sanitary quality of water (APHA).

4.2.8 Sulphate: -

Sulfate ions (SO_4^{2-}) occur in natural water and wastewater. The high concentration of sulfate in natural water is usually caused by leaching of natural deposits of sodium sulfate or magnesium sulphate. In drinking water, sulphate limitation 200 mg/L (Drinking).

4.2.9 Fluoride: -

A moderate amount of fluoride ions (F^-) in drinking water contributes to good dental health. About 1.0 mg/L is effective in preventing tooth decay, particularly in children.

4.2.10 Hardness: -

Hardness is a term used to express the properties of highly mineralized waters. The dissolved minerals in water cause problems such as scale deposits in hot water pipes and difficulty in producing lather with soap. Calcium (Ca^{2+}) and magnesium (Mg^{2+}) ions cause the greatest portion of hardness in naturally occurring waters. They enter water mainly from contact with soil and rock, particularly limestone deposits (Drinking).

There are two types of hardness: Temporary hardness which is due to carbonates and bicarbonates can be removed by boiling and Permanent hardness which is remaining after boiling is caused mainly by sulfates and chlorides.

Hardness of water ≥300 mg/L is generally considered as hard, and water with less than 75 mg/L is considered to be soft. Hardness is normally determined by titration with ethylene diamine tetra acidic acid or (EDTA) and Erio-chrome Black and Blue indicators. It is usually expressed in terms of mg/L of $CaCO_3$ (APHA).
Total hardness mg/L as CaCO3 = calcium hardness mg/L a CaCO3+magnesium hardness mg/L as CaCO3.

Table 1: Water Classification as per Hardness.

Water Classification	Total Hardness concentration as $CaCO_3$ mg/L
Soft water	<50 mg/L as $CaCO_3$
Moderately Hard water	50-150 mg/L as $CaCO_3$
Hard water	150-300 mg/L as $CaCO_3$
Very Hard water	>300 mg/L as $CaCO_3$

4.2.11 Dissolved oxygen: -

Dissolved oxygen (DO) is considered to be one of the most important parameters of water quality in streams, rivers, and lakes. It is a key test of water pollution. The higher the concentration of dissolved oxygen, the better the water quality. Oxygen is slightly soluble in water and very sensitive to temperature. For example, the saturation concentration at 20^{O}C is about 9 mg/L and at 0^{O}C is 14.6 mg/L (Nayla el at.,2019).

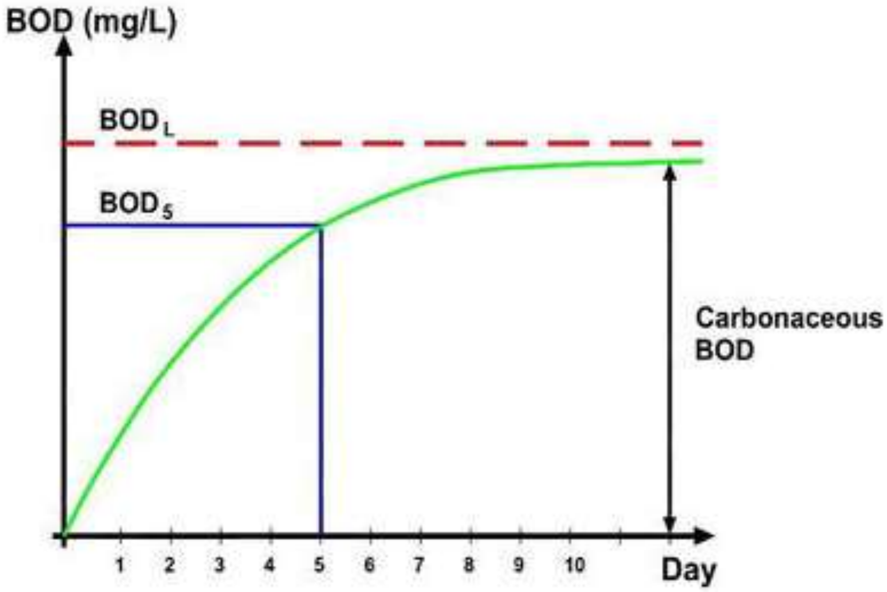


Fig 2: BOD graph curve

4.2.12 Biochemical oxygen demand (BOD): -

Bacteria and microorganisms use organic substances for food. As they metabolize organic material, they consume oxygen. The organics are broken down into simpler compounds, such as CO_2 and H_2O, and the microbes use the energy released for growth and reproduction.

BOD is a function of time. At time =0, no oxygen will have been consumed and the BOD =0. Oxygen is used by the microbes and the BOD increases day by day. The BOD_L is reached and the organic materials are completely decomposed (Nayla el at.,2019**)**.

$BOD_t=BOD_L\times(1-10^{-kt})$ where BOD_t = BOD at any time t, mg/L; BOD_L = ultimate BOD, mg/L; k = a constant representing the rate of the BOD reaction; t = time, d.

4.2.13 Chemical oxygen demand (COD): -

The chemical oxygen demand (COD) is a parameter that measures all organics: the biodegradable and the non-biodegradable substances. It is a chemical test using strong oxidizing chemicals (potassium dichromate), sulfuric acid, and heat, and the result can be available in just 2 h. COD values are always higher than BOD values for the same sample.

4.2.14 Toxic inorganic substances: -

A wide variety of inorganic toxic substances may be found in water in very small or trace amounts.

Metallic compounds: Heavy metals that are toxic, namely, cadmium (Cd), chromium (Cr), lead (Pb), mercury (Hg), silver (Ag), arsenic (As), barium (Ba), thallium (Tl), and selenium (Se). The heavy metals concentration can be determined by atomic absorption photometers, spectrophotometer, or inductively coupled plasma (ICP) for very low concentration.

Nonmetallic compounds: This group includes nitrates (NO^{3-}) and cyanides (CN^{-}), nitrate has been discussed with the nitrogen in the previous section. This causes a blue skin color syndrome, which is called cyanosis and It also causes chronic effects on the central nervous system and thyroid (Nayla el at.,2019**)**.

4.2.15 Radioactive substances: -

Potential sources of radioactive substances in water include wastes from nuclear power plants, industries or medical research using radioactive chemicals and mining of uranium ores etc. When radioactive substances decay, it releases beta, alpha, and gamma radiation. Exposure of humans and other living things to radiation can cause genetic and somatic damage to the living tissues.

4.2.16 Biological parameters of water quality: -

Biologists can survey fish and insect life of natural waters and assess the water quality on the basis of a computed species diversity index (SDI). Microorganisms exist everywhere in nature. Human bodies maintain a normal population of microbes in the intestinal tract; a big portion of which is made up of coliform bacteria.

4.2.17 Bacteria: -

Bacteria are considered as single-celled plants because its cell structure and the way they ingest food. Bacteria occur in three basic cell shapes: rod-shaped or bacillus, sphere-shaped or coccus, and spiral-shaped or spirellus.

Under favorable conditions of food supply, temperature, and pH, bacteria can reproduce so rapidly that a bacterial culture may contain 20 million cells per millilitre just one day. Bacteria required oxygen for their metabolism, called aerobic bacteria, while they live in oxygen-free environment are called anaerobic bacteria. At low temperatures, bacteria grow very slowly. As temperature increases, the rate of growth and reproduction doubles in every additional $10^{O}C$ and the majority of the species of bacteria having an optimal temperature of about $35^{O}C$.

4.2.18 Testing for coliforms: membrane filter method: -

The filter, a flat paper-like disk, has uniform microscopic pores small enough to retain the bacteria on its surface while allowing the water to pass through. The filter paper is then placed in a sterile container called a petri dish, which contains a special culture medium that the bacteria use as a food source.

The petri dish is usually placed in an incubator, which keeps the temperature at $35^{O}C$, for 24 h. After incubation, colonies of coliform bacteria each containing millions of organisms will be visible (Nayla el at.,2019**)**.

Chapter -5

Methodology

5.1Introduction: -

Methodologies achieving due to various actions of the research objectives are discuss in this chapter. The flow chart depicts the different actions carried out during the study. The following is a more extensive description of the methodology (fig: 3)

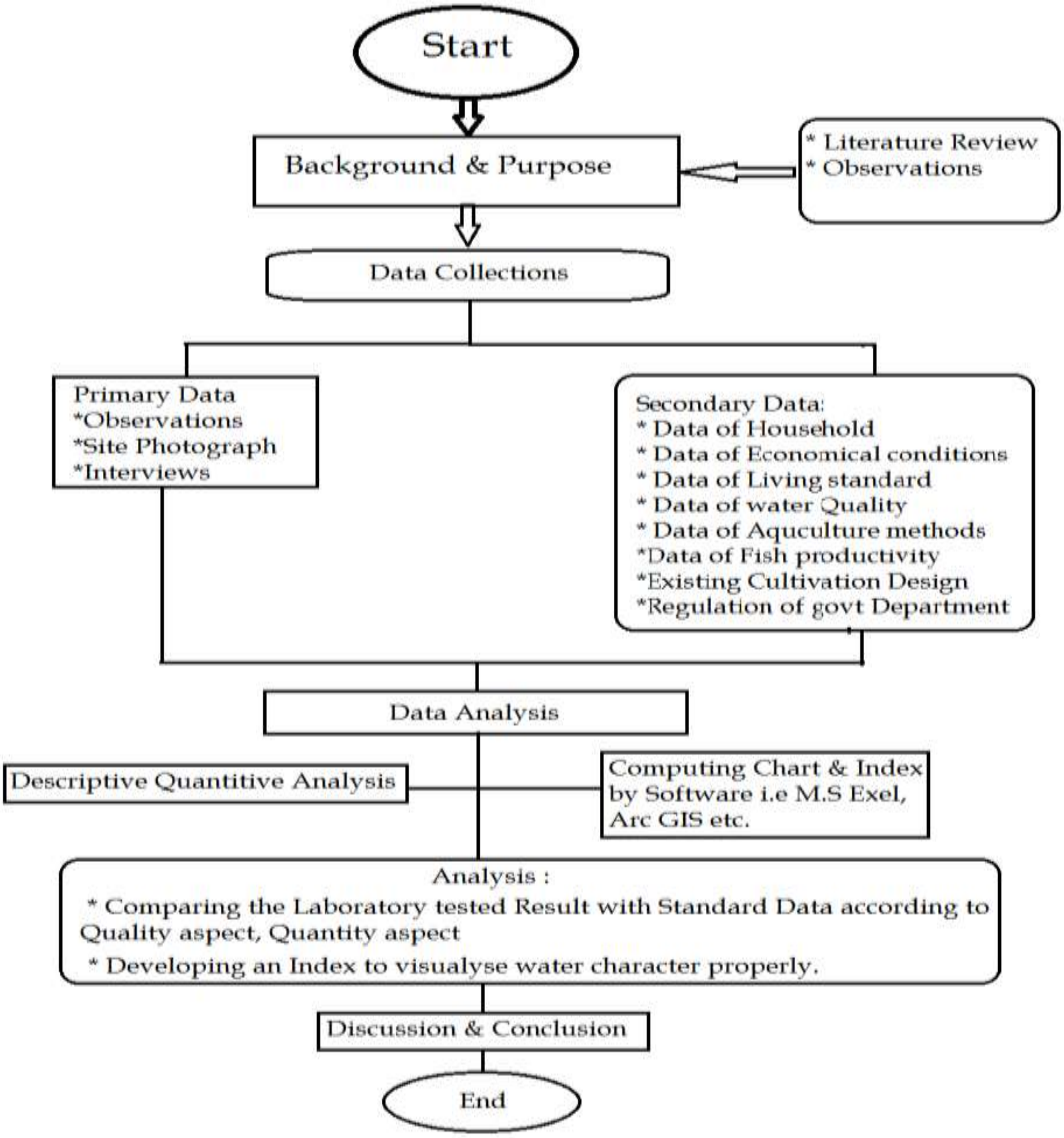


Fig.3: Diagram of Methodology

5.2Materials and Methode:

The present study was carried out just before starting of rainy season. Water samples were collected from four different sampling sites including two sites of canal inlet and outlet water as Haroa canal inlet (GPS-3) and Haroa canal outlet (GPS-4) aquaculture ponds. The water samples were collected between 8.30 a.m. to 9.30 a.m. using wide mouth sterile transparent plastic jar of one-litre capacity and usually from 30-60 cm depth from the water surface. For the analysis of dissolved oxygen (DO), water samples were collected by BOD bottles of 300 ml capacity. The Manganese sulphate ($MnSO_4$) and the Sodium iodide–azide reagent were added immediately at the collection site to fix the samples for studying dissolved oxygen shows precipitate quickly. Then the sample brought in the laboratory within 3 to 4 hours. The measurement was carried out in the laboratory as per APHA and BIS guideline. The water temperatures were measured at the place of sampling sites using standard mercury thermometer. Immediately after arrival in to the laboratory the conductivity of the samples were measured with the help of a digital conductivity meter. For the study of nitrate, phosphate-phosphorus, calcium hardness, magnesium hardness, and total hardness the samples were analysed in the laboratory following standard methods of American Public Health Association (APHA, 23rd edition). The results of analysis were expressed as mg/L except temperature and conductivity measured as 25°C and µmhos/cm respectively.

5.3Site Photograph: -

Fig.4: Sample collecting from Kholdanga ponds.

Fig.5: Haroa Canal outlet of ponds

Fig.6: Haroa Canal Inlet of ponds

Fig.7: Pranab pukur Ponds near canal outlet

Fig.8: sample collecting from ponds

Fig.9: Fixing Dissolve Oxygen and measuring temperature at site.

5.4 Laboratory Experiment: -

Experiment No: 1

Name of The Experiment: Determination of pH Value of the Given Water Sample

Objective: To determine the pH value in the given sample of water

Significance of the Test:

It is the logarithm of the reciprocal of the hydrogen ion activity in moles per liter. The practical pH scale extends from 0 (very acidic) to 14 (very alkaline) with the middle value (pH=7) corresponding to exact neutrality at 25°C. Whereas ‘alkalinity’ and ‘acidity’ express the total reserve or buffering capacity of a sample, the pH value represents the instantaneous hydrogen ion activity. This determination is useful in calculation of carbonate, bicarbonate, hydroxyl and carbon dioxide and in calculation of the extent of corrosion or stability index and in controlling the water treatment process, especially during coagulation and disinfections and water softening.

Available Methods:

There are two methods in determination of pH value, these are:

- **Colorimetric Method:** This method requires less expensive equipment but suffers from source interference contributed by color, turbidity, high saline content, colloidal matter, free chlorine and various oxidants and reluctant. It is only suitable for rough estimation.

- **Electrometric Method:** The electrometric method which is considered standard is given by a Glass Electrode Method. The Glass Electrode Method is relatively immune to the interference from color, turbidity and other previously mentioned factors. It is suitable for very exact estimation (+/-0.1 pH unit).

The measurement of pH is performed electrometrically using a pH meter. The electrode should never be allowed to dry out and therefore must be returned to a beaker or bottle of either pH4 buffer or standard electrode filling solution between measurements. In the absence of either of these solutions, distilled water can be used but the electrode should not be stored for any great length of time in this. The principal of the probe requires the glass electrode to adsorb a layer of the sample on to its surface. The resultant potential difference being a function of the hydrogen ion (H^+) concentration in the sample and the electrolyte contained within the electrode. Prior to measurement the pH meter is calibrated using a freshly made buffer solution (pH 7) and the slope of the electrode adjusted against a pH 4 buffer. Temperature compensation is adjusted manually according to the ambient sample temperature. The electrode is thoroughly rinsed with distilled water before each measurement. Water samples should be collected in a clean glass beaker well flushed with the sample and the electrode allowed to stand for several minutes without agitation before the pH value is determined.

Pure water undergoes dissociation in the following way

$H_2O = H^+ + OH^-$

When this reaction reaches the equilibrium condition we can write

$[H^+]\ [OH^-]$ = equilibrium constant or ionization constant

$[H_2O] = K_{ion}$ [At 25°C temperature $K_{ion} = 1.82\times10^{-16}$]

Since the weight of one litre of water at 25^o C = 997 gms

No. degree of gm/litre of solution = 997/18 = 55.3

$[H^+][OH^-] = 55.3 \text{ x } 1.82 \text{ x } 10^{-16}$

$= 10^{-14} = K_w$[This is $K_{ion}[H_2O] = K_w$ is called ion product constant of water]

Taking common logarithm on both side

$\log[H^+] + \log[OH^-] = \log K_w$

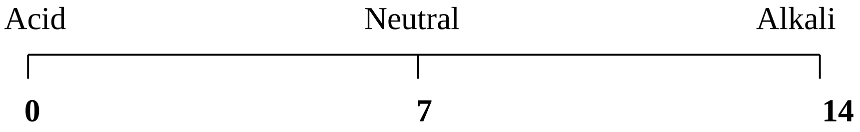
$r\text{-} \log[H^+] + \log[OH^-] = -\log K_w$

By definition in electronatural condition

$[H^+] = [OH^-] = 10^{-7}$ moles / litre

pH = pOH = 7

The pH scale is usually represented as ranging from 0 to 14 with pH = 7 representing absolute neutrality.



pH scale

Fig 10: Digital pH Meter

Fig 11: Digital pH Meter 2

New development:

1. The **HI98129 Combo** tester from Hanna Instruments is designed for fast, efficient and high accuracy pH, EC/TDS and temperature measurements. No more switching meters to measure the pH and then the EC or TDS of a solution. This tester has a hold feature to prompt the user when to take the reading & a display freeze for easy and accurate recording. Calibration and temperature compensation is automatic. The combo has a replaceable pH electrode cartridge and an EC/TDS graphite electrode which resists con-

tamination. The temperature probe is stainless steel, for faster and more precise measurement. The **Combo** is supplied complete with HI 73127 pH electrode, 4 x 1.5V batteries and electrode replacement tool (HI 73128).

Fig 12: Hanna pH meter

Specification		
Range	EC	0 to 3999 µS/cm
	TDS	0 to 2000 ppm
	pH	0.00 to 14.00 pH
	Temperature	0.0 to 60.0 °C or 32.0 to 140.0 °F
Resolution	EC	1 µS/cm
	TDS	1 ppm
	pH	0.01
	Temperature	0.1 °C or 0.1 °F
Accuracy (@ 20°C/68°F)	EC/TDS	±2% Full Scale
	pH	±0.05
	Temperature	±0.5 °C or ±1 °F
Typical EMC Deviation	EC/TDS	±2% Full Scale
	pH	±0.02
	Temperature	±1 °C or ±1 °F
Calibration	EC/TDS	Automatic at 1 point
	pH	1 or 2 points with 2 sets of memorized buffers
Temperature Compensation	EC/TDS	BETA (ß) = adjustable from 0.0 to 2.4 per °C in increments of 0.1
	pH	Automatic
EC / TDS Conversion Factor		Adjustable from 0.45 to 1.00
Environment		0 to 50°C (32 to 122°F)
Battery Type / Life		4 x 1.5V / 100 hours
Auto Shut-off		After 8 minutes
Dimensions		163 x 40 x 26 mm (6.4 x 1.6 x 1.0")
Weight		85 g (3 oz.)

2. LaMotte pH PLUS DIRECT Digital pH Meter

The pH PLUS DIRECT uses a microprocessor to put laboratory precision into a portable water-resistant design. Read pH (with ±0.002 pH accuracy), mV (with ±0.1 pmV accuracy), temperature and concentration (with ±0.5% pH accuracy) with accuracy. The pH PLUS DIRECT allow you to use ISEs to read concentration in ppm It has enough memory for 25 test results. The microprocessor makes the unit easy to use in any test mode.

Fig13: La Motte pH Plus Direct Digital pH meter

	pH	**mV**	**Temperature**	**Concentration**
Range	-2.00 to 19.99	±1999.9	-5.0 to 1000°C	0.0000 to 19999
Resolution	0.01	0.1 mV	0.1#176;C	±1 LSD
Accuracy	±0.002	±0.1 mV	±1#176;C	±0.5% or ±1 LSD
Calibration	3 point manual or automatic	-	-	-
Electrode	Epoxy, Ag/AgCl	-	-	-
Inputs	-	-	-	1 BNC, Temp probe, power, ref.
Power	-	-	-	9V alkaline or line for 110 or 220

Method we followed:

Reagent Preparation: Standard buffer solution of known pH values are prepared by mixing commonly available pH table having pH values 4.01, 7.0 & 9.2 respectively. Each buffer solution has a volume of 100 ml with a single tablet into it.

Description of Procedure:

a) The test cell is filled with KCL solution
b) The temperature is adjusted to the test temperature 25° C
c) Standard buffer solution is taken. If there is any discrepancy between the actual pH value and the pH value obtained in the scale, we have to adjust it and bring it to the actual value by operating the buffer switch.
d) We have to standardize the entire pH meter between the range (4.01 to 7.0) or (7.0 to 9.2).
e) After this standardization process we should take the water sample in the glass bucket and measure its pH value from the scale.

Overview of the experiment:

CALCULATION: -

SAMPLE NO.	pH Value	Temperature Correction factor	Actual PH Value
1	7.964	0.084	7.88
2	8.075	0.075	8.0
3	7.723	0.063	7.66
4	7.567	0.057	7.51

For sample no 1

pH value = 7.964

Temperature correction factor (when temperature= 27.8) = (0.03x (27.8-25)) =0.084

So actual pH value = (7.964) - (0.084) =7.88

Sample no	Actual pH value	Comments
1	7.88	The pH value of all the samples lie within the permissible limit of (7.0 – 8.5) as recommended by **CPHEEO** for domestic purposes. The water sample obtained from Subhash Sarobor is suitable for drinking purpose from pH point of view since a pH value of (7.6-7.9) is very close to 7.0, which denotes complete neutrality. The nature of the water (i.e. whether corrosive or depositive) can be predicted if the saturation pH value of the water sample is available.
2	8.0	
3	7.66	
4	7.51	

Value of pH is always depending on the temperature of the atmosphere. So when we calculate the pH value of the samples, it is essential to determine the temperature correction factor first, as the temperature of the atmosphere fluctuating very much during the experiment.

EXPERIMENT NO: 2

Name of The Experiment:

Determination of Electrical Conductivity of the Given Water Sample.

Objective:

To determine the Electrical Conductivity of the given sample of water by the help of Eco Scan Conductivity Meter.

Significance of the Test:

Electrical conductivity is the property of a substance which enables it to serve as a channel or medium for electricity. It is defined as the ratio between the current density (J) and the electric field intensity (e) and it is opposite of the resistivity (r, [W*m]).

$$S=J/e=1/r$$

The basic unit of measurement of electrical conductivity is microSiemens per centimeter (µS/cm) or deciSiemens per meter (dS/m). MicroSiemens per centimeter are sometimes called EC units. Its symbol is K_s. A common misconception about water is that it is a powerful conductor of electricity.Any electrical properties observable in water are due to the ions of mineral salts and carbon di oxide dissolved in it . Water does self-ionize where two water molecules become one hydroxide anion and one hydronium cation, but not enough to carry enough electrical current to do any work or harm for more operations. Pure water can also be electrolyzed into oxygen and hydrogen gases but without dissolved ions, this is a very slow process and thus very little current is conducted. A number of applications are made of specific conductance measurements, as follows:

- The purity distilled and de-ionized water can be checked by this determination.
- The variations or changes in the dissolved mineral concentration of natural water and waste water samples can be quickly noted.
- Specific conductance measurements make possible the determination of the ionic reagent needed in certain precipitation and neutralization reactions, the end being denoted by a change in the slope of conductivity curve.
- These data can be used to estimate the sample size necessary for other chemical analysis.
- These data also give an offer to check the results of a chemical analysis.
- Electrical Conductivity (EC) estimates the amount of total dissolved salts (TDS), or the total amount of dissolved ions in water. This total dissolved solids information is used to determine the overall ionic effect in a water source. The amount of dissolved ionic matter in a sample may often be estimated by multiplying the specific conductance by an empirical factor which generally varies from 0.5 to 0.90. The proper factor is given by

Equivalent Conductance (Δ) = $(1000 * K_s) / N$

Where, N= Normality of the solution. In dilute solution TDS and EC are reasonably comparable and the TDS of a water sample based on the measured EC value can be calculated using the following equation:

Total Dissolved Solids (mg/l) $= 0.5 * EC$ (dS/m or mmho/cm)

$= 0.5 * 1000 * EC$ (mS/cm)

The above relationship can also be used to check the acceptability of water chemicals analysis. It does not apply to raw waste water or high strength industrial waste water.

As the solution become more concentrated (TDS>1000 mg/l, EC> 2000 ms/cm), the proximity of the solution ions to each other depresses their activity & consequently their ability to transmit current, although the physical amount of dissolved solids is not affected. At high TDS values, the ratio TDS/EC increases & the relationship tends toward

$$TDS=0.9\times EC$$

In these cases, the above mentioned relationship should not be used & each sample should be characterized separately. For water for agricultural & irrigation the purpose the values for EC & TDS are related to each other & can be converted with an accuracy of about 10% using the following equation:

$$TDS\ (mg/l) = 640 \times EC\ (ds/m\ or\ m\text{-}mho/cm)$$

With the reverse osmosis process water is forced in a semi-impermeable membrane leaving the impurities behind. This process is capable of removing 95-99 % of TDS, providing pure or ultra-pure water.

Available method:

Electrical conductivity is measured by applying an electrical potential across two electrodes or plates immersed in a test solution, one of which detects an electrical current sent by other. It can be determined from the voltage & the current intensity produced within the conductivity cell. Electrical conductivity measurement is affected by the geometry of the cell, the total surface of the electrodes (S & the distance separating them (L). These last two parameters define the cell constant:

$$\text{Cell Constant} = L/S$$

The grater the surface of the electrodes, the higher the current intensity generated for a specific voltage & the more accurate the reading of the current. In the following, there are some conductivity cells which can be used to measure electrical conductivity:

1. *Bar type Cell:*

In bar type cell, there are bar rod types cells where the electrodes are made of two bars of metal with a thermistor protected under an epoxy layer. This type of cell is generally fitted in a Tee on a water line & a high flow rates the water flow becomes turbulent across the electrodes resulting in a measurement that is less accurate. At low flow rates, water may be static between the electrodes or dead legs leading to variable readings as well. These cells have a small electrode surface & therefore a relatively high cell constant.

The cell constant is 0.3 in general which makes them inappropriate for the measurement of high receptivity water. Any change in the distance between the electrodes will affect the cell constant & consequently, the accuracy of the conductivity measurement

2. Millipore coaxial type cell:

Made of stainless steel & chemically inert, the Millipore cell is a coaxial cell with a central electrode inside a tubular electrode. Due to the large surface of the electrode & the small distance between them, the cell constant of this cell is 0.01. The design of the cell ensure that the cell constant remains constant. Both the surface of the electrodes & there average distance apart cannot vary with time. Located inside the central electrode, the thermistor is entirely protected & its accuracy of +- 0.1^0C results in highly precise temperature measurement. Ionic species consider in the compensation of resistivity measurement at 25^0 C is Na+, Cl-, H+ & OH-. This cell design has other benefits such as there is no water stagnation & no turbulent water flow.

As a result, resistivity measurement is accurate at all flow rates. This is why Millipore systems providing high quality water carry out real time continuous tests on the validity of the water quality measurement systems.

There are some other methods for the measurement of the electrical conductivity, such as:

3. Four Electrode Measurement Techniques:

Four electrode measurements applies AC through the sample via through outer drive electrodes. These electrodes may become fouled. The circuit will compensate to maintain the AC current level constant.

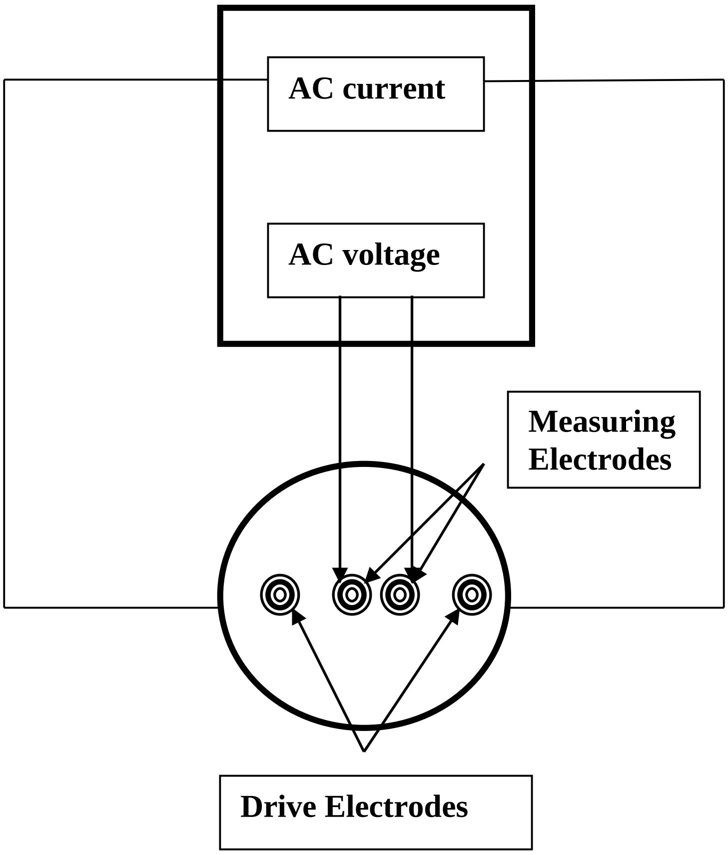


Fig14: Four Electrode Measuring Instrument

Two inner measuring electrodes are used to sense the voltage drop through the portion of solution between them. The circuit makes a high impedance AC voltage measurement, drawing negligible current.

4. Inductive Conductivity Measurement Techniques:

Inductive conductivity measurement is made without any direct electrical contact with the sample. The sensor consists of two parallel coils sealed within a doughnut-shaped insulated probe. The instruments energize one coil with AC. A weak AC current is induced into the surrounding sample, depending on the conductivity. That current in turn induces a signal into the measured coil which provides the measurement signal.

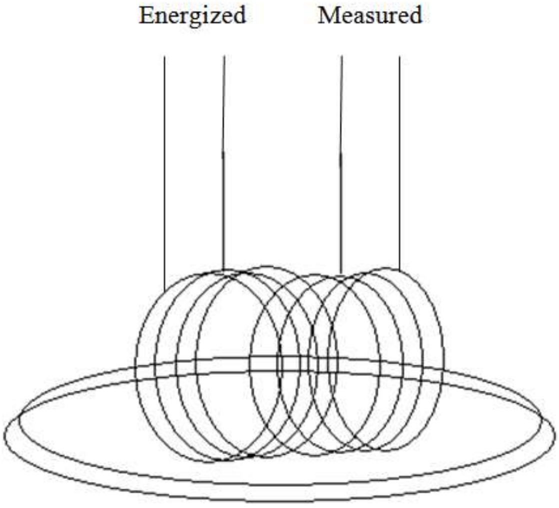


Fig15: - Inductive Conductivity Measurement Techniques

Because there are no electrodes in contact with the sample, extreme fouling conditions can be tolerated. Coatings can cause errors only if there is so much accumulation that it reduces the diameter of the hole. Car is needed in installation of inductive sensors to allow for the specified spasing around it. Otherwise the cross section of sample immediately around the probe or cell constant will be affected & recalibration may be required.

E. Method we followed:

For our experiments we have selected water of Subhash Sara bar to determine the electrical conductivity value. In the laboratory, we measure the electrical conductivity with the help of Eco-scan CON5 Conductivity meter. The principal of the Eco-scan CON5 Conductivity meter is discussed below:

Description of Keypad Function: The Eco-scan CON5 meter has six keys on the splash proof key ped. These comprise ON/OFF, HOLD/ENTER, MODE,⍒& Δ Keys.

ON/OFF: It is used to power the meter on & turn it off. The meter directly enters the measurements modes when it is switched on.

MODE: It is used to select measurement mode for conductivity.

CAL: It allows the calibration mode for conductivity or to abort calibration without confirming any set value.

HOLD: It freezes the measured readings for easy viewing.

Enter: It confirms calibration value.

UP/ DOWN Key: It scrolls up & down to the values during calibration.

Description of LCD Enunciators:

The meter has a large custom LCD that consist of $3^{1/}2$ digit segments & operation enunciators for uS / mS or ppm / ppt & ^{0}C (temperature). Other enunciators include “HO’’ (When Hold function is activated) & “LO” (Low battery condition).

Connecting the Electrode & Temperature Sensor:

To connect the electrode into the meter, the connector slots are aligned with the posts of meter’s socket & the connector is rotated clockwise until it locks. It should not be forced when connecting. To remove, connector is simply rotated in anti-clockwise direction until it unlocks & the connector is slide off the socket.

Switching The Meter on:

1 First of all, the ON/OFF key is pressed to power up the meter. All LCD segments display momentarily as the meter performs a self-diagnostic test. The LCD swathes into conductivity or TDS measurement mode.

2 The mode key is pressed to choose the desired mode of measurements with its corresponding enunciators displays in the LCD. For temperature mode, the measured reading can be 25^{0}C (Factory default) or the last calibrated temperature value if there is no temperature probe or the current measured value if a temperature probe is connected.

3 The LCD displays “UR” if the meter reading exceeds the maximum or “OR” if under minimum possible measurement range.

Conductivity Calibration:

The meter is capable of calibrating 1 point per range (3 points across entire measurements range). If a range is not calibrated, the meter automatically detects the closets range calibrated & uses the calibration information. Calibrate to all measurement ranges to ensure the highest accuracy throughout all measurement range.

1 A known standard solution e.g. 1413 µS /cm into a clear container was poured. The power is on the meter & the meter will automatically enter conductivity measurement mode.

2 The Electrode was immersed sufficiently into one of the containers of the stander solution It was stirred gently & was waited for the reading to stabilize. The electrode was tapped lightly on the bottom of the container to remove any air bubbles trapped.

3 The CAL key was pressed to enter calibration mode. The LCD shows “CA” momentarily & the displays shows the factory calibrated value flashing.

4 The up or down key was pressed to scroll the reading until the displayed value matches the standard solution i.e., 1413 µS /cm.

5 The ENTER key was pressed to confirm calibration & the LCD displays the new set reading & revert to measurement mode.

6 Alternatively, it can be aborted the new calibrated value by pressing the CAL key to exit from calibration mode.

***Description of procedure*:**

1. To begin the measurement, the probe was rinsed thoroughly with de-ionized water to remove any impurities.
2. the meter is powered on & the meter will go automatically into conductivity measurement mode. The MODE key was pressed to select mode of operation between conductivity & temperature.
3. The probe was dipped sufficiently with the tip of the probe completely immersed into the sample. It was stirred & was tapped gently to remove any air bubbles trapped. It should be waited for the reading to stabilize. Then the reading was noted.
4. To freeze or hold the reading, the hold key was pressed once. The LCD displays "HO" enunciator to indicate the HOLD function is activated.
5. The HOLD key was pressed again to deactivate the HOLD function or the realize the frozen reading. The returns to measurement mode & the "HO" enunciator disappear from the LCD.

EXPERIMENT NO: 3

Name of The Experiment: Determination of Dissolved Oxygen Concentration of the Given Water Sample

Object: - To determine Dissolved Oxygen (DO) concentration in a given sample of water.

Introduction*: -* Dissolved Oxygen (DO) levels in natural and waste water are dependent on the physical, chemical and biochemical activities prevailing in the water body. The analysis of DO is a key test in water pollution control activities and waste treatment process control. Two methods for DO analysis are described as the Winkler or iodometric method and its modifications and the electrometric method using membrane electrodes. The iodometric method is a titrimetric procedure based on the rate of diffusion of molecular oxygen across a membrane. The choice of test procedure is dependent on the interface present, the accuracy desired and, in some cases, convenience or expedience.

Significance*: -* The low solubility of oxygen is the major factor that limits the purification capacity of natural water and necessitates waste water treatment to remove polluted matters before discharge to receiving streams.

The aerobic biological treatment processes, the limited solubility of oxygen is of great importance because it governs the rate at which oxygen will be absorbed by the medium.

In liquid wastes, dissolved oxygen is the factor that determines whether the biological changes are brought about by aerobic or non-aerobic organism. The former uses free oxygen for oxidation of organic and inorganic matters and produce end products, whereas the latter brings about such oxidation through the reduction of certain inorganic salts such as sulfates and the end products are often very obnoxious. Thus the dissolve oxygen measurement is vital for maintaining aerobic conditions in natural water that receive polluted matter and in aerobic treatment process intended to purify domestic and industrial waste water.

It is one of the most important single tests that the environmental engineers use to maintain conditions favorable for the growth and reproduction of a normal population of fish and other aquatic organism by maintaining the dissolved oxygen level to support the desired aquatic life in a healthy condition at all times. Thus controlling the stream population.

Determination of dissolved oxygen serve as the basis of B.O.D. test thus to evaluate the pollution strength of wastes and the rate of biochemical oxidation.

Oxygen plays a significant factor in the corrosion of iron and steel, particularly in water distribution systems and steam boilers. Removal of oxygen from boiler feed water by physical and chemical means is a common practice in the power industry.

Selection of Method: - More commonly used procedures are:

1. **Azide modification** → Effectively removes the interferences caused by nitrite, which is the most common interference in biologically treated effluents and incubated BOD samples.

2. **Permanganate modification** → Used in the presence of ferrous iron.
3. **Alum flocculation** → Used in the presence of suspended solids, which cause interference.
4. **Copper Sulfate** → Sulfuric acid flocculation modification → used in activated- sludge mixed liquors.
5. **DO Meter** → Used digital techniques.

Manual procedure (Azide modification): -

Reagents Preparation: -

(a) Manganese sulfate solution: - Dissolve 480g $MnSO_4$, 4 H_2O; or 400g $MnSO_4$, 2 H_2O or 364g $MnSO_4$, H_2O in distilled water, filter, and dilute to 1 liter. The manganese sulfate solution should not give a color with starch when added to an acidified solution of potassium iodide.

(b) Alkali – Iodide – Azide reagent: - The reagent may be prepared in the traditional way, Dissolved 500g Sodium hydroxide, NaOH (or 700g KOH) and 135g of NaCl (150g KI) in Distilled water and dilute to 1 liter. To this solution add 10g Sodium azide, (NaN_3) dissolved in 40ml-distilled water. Potassium and sodium salts may be used interchangeably. This reagent should not give a color with starch solution when diluted and acidified.

(c) Sulfuric Acid, conc.: **-** The strength of this acid is about 36N, hence 1ml is equivalent to about 3ml of the alkali – iodide – azide reagent.

(d) Starch: - Either the aqueous solution or soluble Starch Powder mixtures may be used. Prepare the aqueous solution by adding a cold water suspension of 5g arrowroot or soluble starch to approximately 800ml of boiling Water, with stirring, dilute to 1 liter; allow boiling a few minutes and let settle overnight. Use the clear separate.

(e) Sodium thiosulfate stock solution, (0.10N): - Dissolve 24.82g $Na_2S_2O_8$, $5H_2O$ in boiled and cooled distilled water and dilute to 1 liter. Pressure by adding 5ml chloroform or 1g NaOH per liter.

(f) Standard Sodium Thiosulfate Titrant, (0.0250N): - Prepare either by diluting 250.0 ml Sodium thiosulphate stock Solution to 1000ml or by dissolving 6.205g $Na_2S_2O_3$, $5H_2O$ in freshly boiled and cooled distilled water and diluting to 1000ml. Standard Sodium thiosulphate solution, exactly 0.0250N is equivalent to 200µg DO per 1.00ml.

(g) **Standard Potassium Dichromate Solution, (0.0250N): -** A solution equivalent to 0.0250N sodium thiosulfate contains 1.226 g/l $K_2Cr_2O_7$. The $K_2Cr_2O_7$ should be previously dried at 103˚c for 2hr. The solution should be prepared in a volumetric flask**.**

Standardization: - Dissolved approximately 2g KI, free from iodide, in an Erlenmeyer flask with 100 to 150ml distilled water; add 10 ml 10 H_2SO_4, followed by exactly 20.0 ml standard potassium dichromate solution. Dilute to approximately 400 ml and titrate the liberated iodine with the thiosulfate titrate, adding starch towards the end of the titration, when a pale straw color is reached.

Calculation*: -* Because 1ml 0.0250N Sodium thiosulfate titrant is equivalent to 0.200mg DO, each mm. of sodium thiosulfate titrant used is equivalent to 1 mg/l DO when a volume equal to 200 ml of original sample is titrated.

Digital procedure (DO meter): -

We may find the DO by using DO-meter. Actually in our lab we find the DO by using digital meter. The figure and the specification of the meter are shown below.

Fig 16: DO meter

METER SPECIFICATION AND SOME IMPORTANT NOTE:-

Product Specification	Description
Dissolved Oxygen Range	*0 to 19.9 mg/l or ppm*
Resolution & Accuracy	*0.01 mg/l, 0.1 ppm & ±1.5% Full Scale*
% Saturation of Oxygen	*0.0 to 199.9 %*
Resolution & Accuracy	*0.1 % & ±1.5% Full Scale*
Temperature Range	*0.0 to 50.0 °C*
Resolution & Accuracy	*0.1 °C & ± 0.5 °C*
Barometric Pressure Correction	*500 to 1499 mm Hg or 66.6 to 199.9 kPA*
Method	*Manual input for automatic correction*
Memory	*100 sets*
Power Requirements	*4 x 1.5V batteries; > 700 hrs or 9VDC power adapter*

EXPERIMENT NO. -4

Name of The Experiment: Determination of Bio- Chemical Oxygen Demand of the Given Water Sample

Objective: To determine the Bio- Chemical Oxygen Demand (BOD) in a given sample of water.

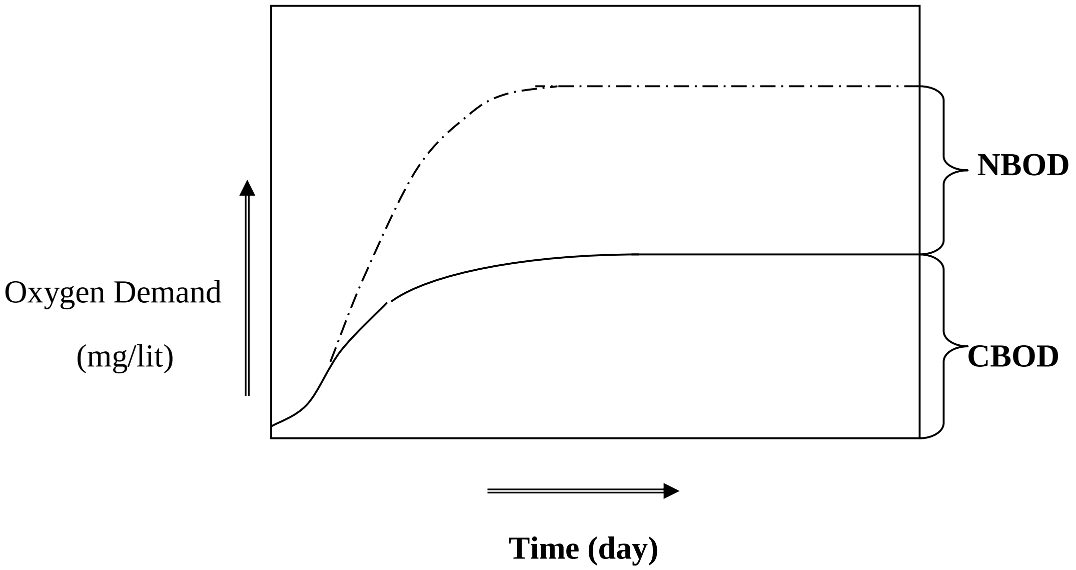
Significance of Test: - Biochemical oxygen demand may be defined as the amount of oxygen required by micro-organism for stabilizing bio-degradable dissolved organic matter under aerobic condition at a standard time and temperature. It is widely used to determine the pollution strength of domestic and industrial wastes in terms of oxygen that they will require if discharged into natural watercourses in which aerobic condition exists. The test is one of the most important in stream pollution control activities where organic loading must be restricted to maintain desired DO level. The determination is used in studies to measure the purification capacity of streams and serves regularly authorities as a means of checking on the quality of effluents discharged to such waters.

Information concerning the BOD of wastes is an important consideration in the design of treatment activities. It is a factor in the choice of treatment method and is used to determine the size of certain units, particularly trickling filter actuated sludge units.

Theoretical Background: BOD is the most commonly used parameter to determine relative oxygen requirements i.e. the strength of different types of waste water. In the standard test a 300 ml bottle is used and the sample is incubated at 20ºC for 5 days. This 5 day - 20ºC BOD or BOD_5 at 20ºC is the most common and widely used parameter to organic pollution. $BOD_{5\ at\ 20}$ºC may be defined as first stage BOD exerted in 5 days at a test temperature of 20ºC. First stage BOD means only carbonaceous oxygen demand and it does not include the nitrogenous oxygen demand, the oxygen required for the nitrification process that is conversion of NH_3-nitrogen into NO_2^- nitrogen and NO_2^- nitrogen into NH3 nitrogen. So we can write:

Total Biochemical Oxygen Demand, (2nd stage BOD) = CBOD + NBOD

When we have first stage and second stage at same time we can call it combined BOD. The sketch for exertion of carbonaceous and nitrogenous biochemical oxygen demand for a waste water sample is drawn below.



When sufficient number of nitrifying organic matter is present nitrification can occur s shown in the dotted line. Nitrification usually occur from 5 to 8 days after the start of the incubation period.

Expression for BOD Exertion:

In deducing the expression for BOD exertion the following assumption is made according to the 1st order kinetics.

(Rate of BOD degradation) ∞ amount of organics alredypresent in the kinetics i.e mathematically,

$$dL/dT \infty L$$

or, $$dL/dT \infty -KL$$

or, $$dL/L = -KdT$$

or, $$\int_{Lo}^{Lt} dL/L = -K \int_{0}^{t} dT$$

or, $$\log_e(L_t/L_0) = -kt$$

or, $$L_t/L_0 = e^{(-kt)}$$

or, $$L_t = L_0 e^{(-kt)}$$

Now by definition,

$$y_t = (L_0 - L_t) = L_o [1- e^{(-Kt)}]$$

or $BOD_t = y_t = (L_0 - L_t) = L_o [1- e^{(-Kt)}]$

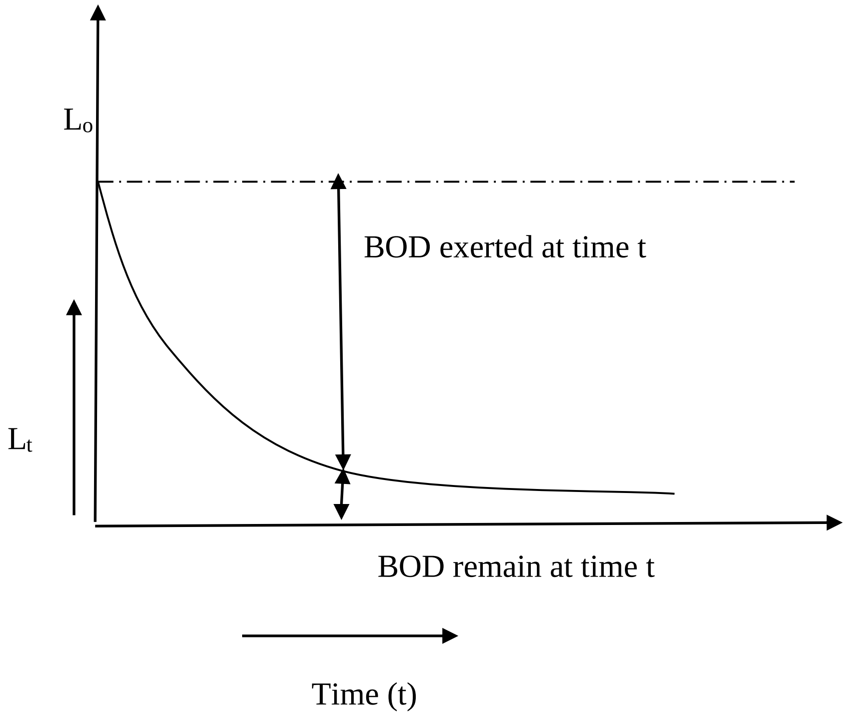
Here L_o = Initial first stage BOD remaining at time t = 0 in mg/lit.

L_t = Initial first stage BOD remaining at time t in mg/lit

$Y_t = (L_0 - L_t)$ First stage BOD exerted in time t in mg/lit.

t = Time in days.

In this context the formation of first stage BOD curve is shown below.



Dependence of Temperature on rate Constant:

The temperature at which the BOD of waste water sample is determined is usually 20^0C. it is possible however to determine the reaction constant, K at a temperature other than 20^0C. the following approximate equation, which is derived from the Hoff – Arrhenius relationship, may be used:

$$K_T = K_{20}\,\theta^{(T-20)}$$

Where θ = temperature Co-efficient = 1.047. Strictly speaking,

$\theta = 1.056$ [when T = (20- 30) ^{0}C]

$\theta = 1.135$ [when T = (04- 20) ^{0}C]

<u>D] Available Methods</u>: **-** Basically BOD determination involves determination of D.O at a particular interval and at a specific temperature (20^0C). BOD measurement is done usually by any one of the following two methods depending upon dissolved oxygen depletion.

I) <u>Direct Method</u>: **-** This method is suitable for those BOD_5 that does not exceed 7mg/lt, provided that they are aerated to bring the dissolved oxygen level nearly to the saturation at the start of the test. This method does not involve any modification of the sample.

II) Dilution Method: **-** This method is suitable for those wastes which pass high BOD_5 value involving high DO depletion if measured directly. Here the sample is diluted to desired degree to have safe DO depletion value. This method can be performed in two ways**:**

- **a)** With seed – Which is performed when the wastewater sample does not contain sufficient amount of microorganism Seed sample containing necessary micro-organism are to be added to the original sample.
- **b)** Without seed – This test is usually performed when the waste water contains sufficient amount of microorganism to biodegrade dissolved oxygen matter.

E] Method we followed: - In our experiment we have selected municipality wastewater to determine the BOD value. Since this sample has a tentative BOD_5 value of 200mg/lt at 20^0C and contain sufficient microorganism for bio-degradation purpose we are to follow dilution method (without seed). Basically the principle of BOD measurement is to be taken as that of DO measurement which is to be discussed later.

BOD Measurement (without seed):-

If f = % of dilution

The dilution factor is given by D = 100/f

Let initial DO concentration $= DO_i$

Let t day DO concentration $= DO_t$

Then t day BOD $= BOD_t = (DO_i - DO_t).\ D$

$= (DO_i - DO_t).\ 100/f$

In this context it is mentionable that BOD is independent of the dilution factor

i.e. $(\text{DO difference})_1 \text{ X } D_1 = (\text{DO difference})_2 \text{ X } D_2$

BOD Measurement (with seed): -

In this type of test, we have to measure separately the DO concentration for seeded sample and seed blank sample. Here, Seeded sample = (Waste + Seed + Nutrient).

Seed (blank) sample = (Seed+ Nutrient)

Usually (1-2) ml. of seed material is required for 1 lit of diluted sample.

If D = Dilution factor for the sample (f= % of dilution)

d_s = Dilution factor of seed in speed blank sample (f_s=Corresponding % of dilution)

d_{ss}= Dilution factor for seed in seeded, (f_{ss} = Corresponding % of dilution)

DO_i = Initial DO for seeded sample

DO_f= Final DO for the seeded sample.

DO_{si}= Initial DO for the seed blank sample.

DO_{sf}= Final DO for the seed blank sample.

$(BOD)_{sample} = [(DO_i - DO_f) – (DO_{si} - DO_{sf}) X (f_{ss}/f_s)] X (100/f)$

<u>Reagent Preparation</u>: -

(1) Nutrients Preparation: **-** Nutrients are required beside the bio-degradable dissolved organic matter for the proper growth of the microorganisms. The following nutrients are added in stipulated quantity within the waste sample.

(2) Phosphate Buffer Solution: **-** It is added in order to maintain a moderately constant ph value. Beside this it also acts as a source of nitrogen and phosphate required as nutrients.

In this case we have dissolved following chemicals-

(a)8.5 gm potassium dihydrogen phosphate.

(b) 21.75gm di-potassium hydrogen phosphate.

(c) 33.4gm dissolve hydrogen phosphate hecta-hydrate or 2.205 gm (Na_2HPO_4, $2H_2O$).

(d) 1.7 gm Ammonium chloride in about 500 ml distilled water Dilute it to 1litre.

(3) $MnSO_4$ Solution: - In this case we have to dissolve 480 gm. manganus sulphate tetra hydrate ($MnSO_4$, $4 H_20$) in boiled distilled water, filter it and dilute to 1 liter.

(4) $CaCl_2$ solution: - Dissolve 2.75 gm anhydrous $CaCl_2$ in distilled water and dilute to 100 ml.

(5) $FeCl_3$ Solution: - Dissolve 0.025 gm, $FeCl_3$,$6H_2O$ in distilled water and dilute it to 100 ml.

(6) Alkali Azide Solution: In this case we have to dissolve 500 gm. Sodium Hydroxide(NaOH) and 135 gm. Of Sodium Iodide (NaI) in distilled water, filter it and dilute to 1 liter.

(7) Starch solution: In this case we have to add 1 gm. Starch in 50 ml. distilled water and then heat the solution so that all the starch dissolves in water and clearance will ppear in upper position.

(8) **$MgSO_4$** Solution: 22.5 gm. Of Magnesium Sulphate Hepta Hydrate ($MgSO_4$, 7 H_2O) has to be added to distilled water and to be diluted to 1 liter.

(9) **Thio- sulphate solution :6.205 gm. Of sodium thio sulphate penta hydrate (**$Na_2S_20_3$, 7 H_2O) has to be dissolved in distilled water and 0.4 gm. Of solid Sodium Hydroxide (NaOH) has to be added to it and the entire solution have to be diluted to 1 liter.

Procedure: -

We have determined the BOD of 6 samples collected from subhash sorobar, kolkata

1. Take 6 ltr. aerated D/D water.
2. The incubator temperature has to be controlled to 20^0C.
3. The nozzle of the aerator should be cleaned and the distilled water have to be aerated by means of a compression for about 45 min in order to raise the initial DO.
4. Add 6 ml each
    a. Phosphate buffer solution.
    b. $MgS0_4$ solution
    c. $CaCl_2$ solution
    d. $FeCl_3$ solution.
5. For lake water take 200 ml sample + 800 ml D/D water in 1 ltr. measuring cylinder.
6. This mixture has to be kept in three nos. of 300ml BOD bottle.
7. similarly, for 18 BOD bottle are filled for 6 sample
8. Keep 12 (2 BOD bottle from each sample) bottle in incubator at 20^0C and remaining 1 from each sample is used for the test as ‘0’day BOD.

Procedure for ‘0’ day DO measuring:

a) Add 2 ml Azide solution + 2 ml $MnSO_4$ solution

b) 15 time shake it, keep it for few minutes and flock will appear.

c) Add 2 ml H_2SO_4 conc. When 1/3 rd flock is cleared. Shake it and iodish color will be seen.

d) Take 200 ml this solution in a conical flask.

e) Titrate it with $Na_2S_20_3$ solution and stop it when light yellow color will be seen.

f) Then add 2 ml starch solution. Deep blue color will be seen. Again titrate with $Na_2S_20_3$. Stop when it becomes colorless.

Note the end point.

S_0 = Reading of $Na_2S_20_3$

BOD (mg/L) = [$(S_5-S_0) - (C_5-C_0)$] × Dilution factor

Dilution factor = 100/20 = 5.

Experiment No: 5

Name of The Experiment: Determination of Chemical Oxygen Demand of the Given Water Sample

Objective: To determine the Chemical Oxygen Demand **(COD)** of the given sample of water

Significance of the Test **:**

Chemical Oxygen Demand (COD) may be defined as the oxygen required for stabilizing both biodegradable & non-biodegradable dissolved organic matter under aerobic condition at a standard time and temperature. This test is widely used as a means of measuring the pollution strength of domestic and industrial wastes. This test allows measurement of a waste in terms of the total quantity of oxygen required for oxidation to CO2 and water. It is based upon the fact that all organic compounds, with a few exceptions, can be oxidized by the action of strong oxidizing agents under acidic condition. The COD test is used extensively in the analysis of industrial wastes. It is particularly valuable in surveys designed to determine and control losses to sewer system. In conjunction with the BOD test the COD test is helpful in indicating toxic condition and the pressure of biologically resistant organic substances.

AVAILABLE METHODS :

There are number of methods available for the COD test. Among these the following are important from the subject point of view:

i) **Open Reflux Method**
ii) **Closed Reflux, Titrimetric Method**
iii) **Closed Reflux, Colorimetric Method**

This method is discussed below:

Open Reflux Method : This is the method we have followed and discussed afterward.

Closed Reflux, Titrimetric Method: Most types of organic matter are oxidized by a boiling mixture of Chromic and Sulfuric acids. A sample is refluxed in strongly acid solution with a known excess of Potassium Di Chromate ($K_2Cr_2O_7$). After digestion, the remaining unreduced $K_2Cr_2O_7$ is titrated with Ferrous Ammonium Sulfate to determine the amount of $K_2Cr_2O_7$ consumed and oxidizable matter is calculated in terms of Oxygen equivalent. The ratios of reagent weights, volumes and strengths should be kept constant when sample volumes other than 50 ml. are used.

Closed Reflux, Colorimetric Method: When a sample is digested, the dichromate ion oxidizes COD material in the sample. This results in the change of chromium from the hexavalent (VI) state to the trivalent (III) state. Both of these chromium species are colored and absorb in the visible region of the spectrum. The dichromate ion ($Cr_2O_7^{2-}$) absorbs strongly in the 400 nm. region, where the chromic ion (Cr^{3+}) absorption is much less. The chromic ion absorbs strongly in the 600 nm. region where the dichromate has nearly zero absorption. In 9(M) of Sulfuric Acid solution the approximate molar extinction coefficients for these chromium species are as follows: Cr^{3+} - 50 lit./mole cm. at 604 nm.; $Cr_2O_7^{2-}$ - 380 lit./mole cm. at 444 nm.; Cr^{3+} - 25 lit./mole cm. at 426 nm. The Cr^{3+} ion has a minimum in the region of 400 nm.

METHOD WE FOLLOWED:

In our laboratory test we use potassium dichromate as oxidizing agent which is actually capable of oxidizing a wide variety of organic substances and almost completely CO_2 and H_2O for that purpose the solution must be strongly acidic and at an elevated temperature. As a result of this elevated temperature significant loss of volatile compound may take place which is prevented by using reflux condenser. Certain organic compounds, particularly low molecular fatty acids are oxidized by dichromate in the presence of silver ions acting as catalyst. However, the reaction involved may be represented by in a general way as follows-

$$C_nH_aO_b + CCr_2O_7 + 8CH^+ \longrightarrow nCO_2 + (a + 8c) / 2\, H_2O + CrO^{3+}$$

$$\text{Where } C = 2n/3 + a/6 - b/3$$

As a result of this reaction chromium is reduced from a state of valence six to that of three.

Measurement of Excess Oxidizing agent : It is necessary for the oxidizing agent to be present in excess to ensure the complete oxidization of all organic matter. To measure this excess and actual amount reduced it is necessary to cue a reducing agent for the dichromate. In our experimental we use 0.1N ferrous ammonium sulphate $Fe(NH_4)_2(SO_4)$, $6H_2O$ as the reducing agent which reacts with dichromate in the following way :

$$6Fe^{2+} + Cr_2O_7^{-2} + 14H^+ \longrightarrow 6Fe^{3+} + 2Cr^{3+} + 7H_2O$$

Blank sample are required for this test in order to get mid of the interference of the organic matter, extraneous by nature.

Inorganic Interferences : Certain reduced inorganic ions can be oxidized under this condition thus giving erroneously high result. Chloride causes the most serious problem because of its usual high concentration in wastewater.

$$6Cl^- + Cr_2O_7^{-2} + 14H^+ \longrightarrow 3Cl_2 + 2Cr^{3+} + 7H_2O$$

This interference can be eliminated by the addition of $HgCl_2$

$$Hg^{2+} + 2Cl^- \leftrightarrow HgCl_2$$

The interference of NO^{2-} can be overcome by the addition of sulphuric acid to the dichromate solution. Ag_2SO_4 is added in order to oxidize organic compounds particularly low-molecular weight fatty acids.

Reagent Preparation **:**

1. *Standard Potassium Dichromate Solution (0.25 N)* **:** Appropriately 15 gm of $K_2Cr_2O_7$ was dried at 103^0C for 2 hrs . Exactly 12.259 gm of specially dried orange crystal was dissolved in double distilled water (D.D) and dilute to exactly 1 litre .
2. *Ferrous Ammonium Sulphate Solution (FAS) (0.25 N)* **:** 98 gm of $Fe(NH_4)_2SO_4$, $6H_2O$ was dissolved appropriately in 600 ml D.D . 20 ml of concentrated H_2SO_4 was then added and allowed to cool and diluted to 1 litre with D.D .
3. *Mercuric Sulphate* : Powdered $HgSO_4$.
4. *Ferrous indicator Solution*: 1.485 gm 1, 10 Phenolthroline Mono Hydrate was dissolved together with 0.695 gm $FeSO_4$, 7 H_2O in distilled water and diluted to 100 ml .
5. *Sulphuric Acid reagent* : 4.4 gm Ag_2SO_4 was taken in 500 ml H_2SO_4 bottle .
6. *Glass Beads*

7. *Standardisation*: 10 ml distilled water was added to 10 ml of 0.25 (N) $K_2Cr_2O_7$ solution with further addition of 20 ml of concentrated H_2SO_4 and then allowed to cool. Then it was titrated with F.A.S. using 1-2 drops of ferrous indicator. The color change is very sharp, going from blue green to reddish brown.

$$\text{F.A.S. Normality} = \frac{(ml\ of\ K_2Cr_2O_7)\times(K_2Cr_2O_7\ in\ Normality)}{ml\ of\ FAS\ used}$$

Standardization:

Volume of titrant (in burette), $Fe(NH_4)_2SO_4,6H_2O = V_1 = 10$ ml

Volume of $K_2Cr_2O_7$ solution = $V_2 = 10$ml

Strength of $K_2Cr_2O_7 = S_2 = 0.25$(N)

We know that: $V_1 \times S_1 = V_2 \times S_2$

Therefore $\boxed{\mathbf{S_1=0.25N}}$

Procedure **:**

I. 25 ml of 0.25 N $K_2Cr_2O_7$,1 gm $HgSO_4$,5.0 ml concentrated H2SO4, 25 ml sample and 30 ml H_2SO_4 solution (Ag_2SO_4) was mixed in a conical flask .

II. About 5 pieces of glass beads was taken in the flask .

III. Then all the flask was heated and refluxed for 2 hrs. (30^0C for 1st hr and 60^0C for next hr) .

IV. All the flask were then allowed to cool and the condenser was washed down with about 25-ml of distilled water .

V. The acid solution was then diluted to about 200-ml with double distilled water and the solution was then allowed to cool to room temperature.

VI. 3 drops of ferrous indicator was then added to the flask.

VII. The excess dichromate was then titrated with 0.25 N $Fe(NH_4)_2SO_4$ solution.

VIII. The titration should be stopped when color changes from blue green to reddish.

Calculation :

$$\text{COD (mg/lt)} = \frac{(A-B)\times 8000\times N}{S}$$

where,

A = ml of $Fe(NH_4)_2SO_4$ solution required for the titration of the blank = 25.8 ml.

B = ml of $Fe(NH_4)_2SO_4$ solution required for the titration of the sample

N = Normally of the $Fe(NH_4)_2SO_4$ solution = 0.25(N)

S = ml of sample used for the titration = 25ml

Proposed Method Modification for the Determination of COD in Saline Waters :

This work presents a modification of the method 5220 D [1] utilizing a digestion apparatus (Hach , model 45600) . The proposed method was tested exhaustively using a synthetic wastewater with variable COD and chloride contents. The results indicate that the proposed modification eliminated the chloride interference on COD determination up to 6000 mg Cl l^{-1} , when the sample COD content was higher than 50 mg l^{-1} .

Experiment No.: 6

Name of The Experiment: Determination of Total Dissolved Solid Concentration by Using TDS Meter of the Given Water Sample.

Objective: To determine the Total Dissolved Solid Concentration of the given sample of water.

Significance of the Test:

Total Dissolved Solids (TDS) are the total amount of mobile charged ions, including minerals, Salts or metals dissolved in a given volume of water. TDS is directly related to the purity of water and the quality of water purification systems and affects everything that consumes, lives in, or uses water, whether organic or inorganic, whether for better or for worse. Some dissolved solids come from organic sources such as leaves, silt, plankton and industrial waste and sewage. Other sources come from runoff from urban areas, road salts used on street during the winter and fertilizers and pesticides used on lawns and farms. Dissolved solids also come from inorganic materials such as rocks and air that may contain calcium bicarbonate, nitrogen, iron phosphorous, sulfur and other minerals. The efficacy of water purification systems in removing total dissolved solids will be reduced over time so it is highly recommended to monitor the quality of a filter or membrane and replace them when required.

D) Sources of Total Dissolved Solids (Minerals) in Drinking Water :

Total dissolved solids (TDS) comprise inorganic salts (principally calcium, magnesium, potassium, sodium, bicarbonates, chlorides and sulfates) and some small amounts of organic matter that are dissolved in water. Many dissolved inorganic water contaminants or impurities exist as ions in solution, the most common of these ions are:

Cations	Anions
Calcium Ca+ +	Bicarbonate HC09$^{\hat{A}}$
Magnesium Mg++	Chloride Cl
Sodium Na+	Sulfate SO,- $^{\hat{A}}$
Iron Fe+ +	Nitrate NO, $^{\hat{A}}$
Manganese Mn+ +	Carbonate CO, $_{--}$

The maximum contamination level (MCL) of 500mg/liter (500 parts per million (ppm) for TDS. Numerous water supplies exceed this level. When TDS levels exceed 1000mg/L it is generally considered unfit for human consumption. A high level of TDS is an indicator of potential concerns, and warrants further investigation. Most often, high levels of TDS are caused by the presence of potassium, chlorides and sodium. These ions have little or no short-term effects, but toxic ions (lead arsenic, cadmium, nitrate and others) may also be dissolved in the water.

The following are reasons why it is helpful to constantly test for TDS:

Taste/Health	High TDS results in undesirable taste which could be salty, bitter, or metallic. It could also indicate the presence of toxic minerals. The EPA's recommended maximum of TDS in water is 500mg/L (500ppm).
Filter performance	Test your water to make sure the filter system has a high rejection rate and know when to change your filter (or membrane) cartridges.
Hardness	High TDS indicates Hard water, which causes scale buildup in pipes and valves, inhibiting performance.
Aquaculture	A constant level of minerals is necessary for aquatic life. The water in an aquarium should have the same levels of TDS and pH as the fish and reef's original habitat.
Commercial/Industrial	High TDS levels could impede the functions of certain applications.

Range of TDS present in the following sources:

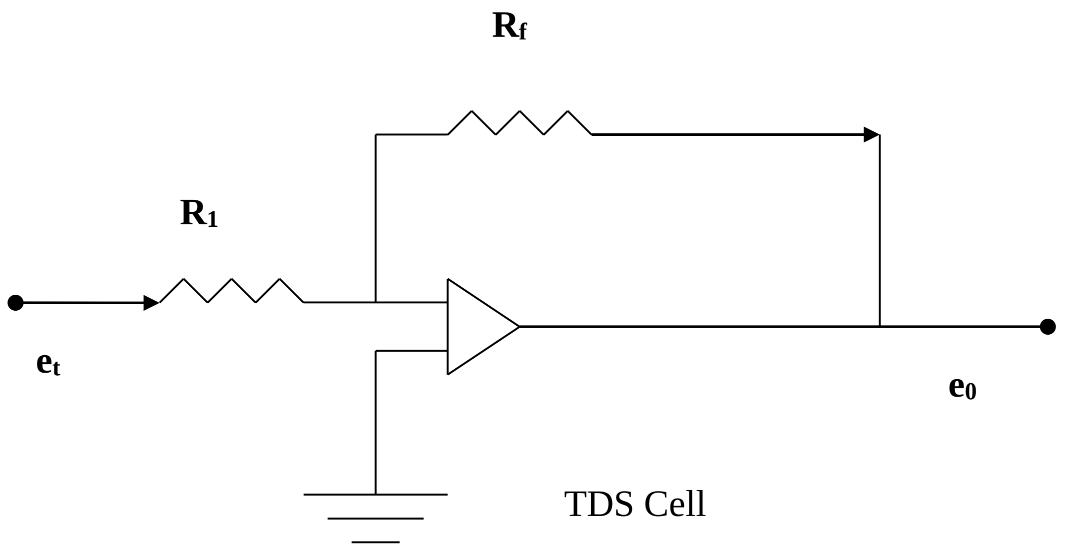
Sources	**TDS**
Ideal Drinking water from reverse osmosis, distillation, deionization, micro filtration, etc..	0-50 PPM
Often considered acceptable range for carbon filtration, mountain springs or aquifers.	50-140 PPM
Average tap water.	140-400 PPM
Hard water.	170 PPM or above
Less desirable	200-300 PPM
Unpleasant levels from tap water, aquifers or mountain springs.	300-500 PPM
The EPA's maximum contamination level.	500 PPM

Available Methods:

- **Method 9015:** Metal Cyanides Complexes by anion Exchange Chromatography & UV detection.
- By **Digital TDS Meter**
- **Method 3511:** Organic compounds in water by Micro extraction.
- **Method 8260c:** Volatile organic compounds by Gas Chromatography/ Mass Chromatography.

Method we followed:

When a TDS cell dipped in a measuring solution is placed in the inverting input of an “operational amplifier” and an AC voltage of the constant amplitude and suitable frequency is applied to the system, then for a given feed back resistance R_f the output e_0 is linearly proportional to the conductance of the solution.



Where $e_o = R_f / R_i \times e_i$

$= K / R_i$ (K is a constant if R_i and e_i are constant)

Digital TDS Meter Model 651E is extremely for fast and accurate determination of Total Dissolved Solids in a liquid. The use of solid state technology and IC circuitry makes this instrument versatile and reliable.

***Technical Specification*:**

Range	**:**	5 Ranges 0-200 ppm 0-2000 ppm 0-20.00 ppt (20000 ppm) 0-2000.00 ppt (2 million ppm)
Resolution	**:**	0.1 ppm
Accuracy		1 % FS + 1 digit
Cell Constant	**:**	Adjustable with indication on display
Temperature Compensation	***:***	0-50^{o} C
TDS Cell	**:**	Platinum Dip Type.
Display	**:**	3 $^{1}/_{2}$ digital LED display
Power	**:**	230 ± 10% AC, 50 Hz
Dimensions	**:**	275 x 175 x 75 mm
Weight	**:**	2 Kg.

TDS Meter:

Fig 17: TDS meter

Front Panel Control:

Digital Display **:** A 3 $^{1}/_{2}$ digital LED display that reads Total Dissolved Solids.

Function Switch **:** This is a 3 position switch with following function:

i. In the CHECK position, the meter should display 1000 ignoring position of the decimal point. If necessary, the reading with CAL control was adjusted provided ad the back of the instrument.

ii. In the TDS position it measured total dissolved solids in the solution.

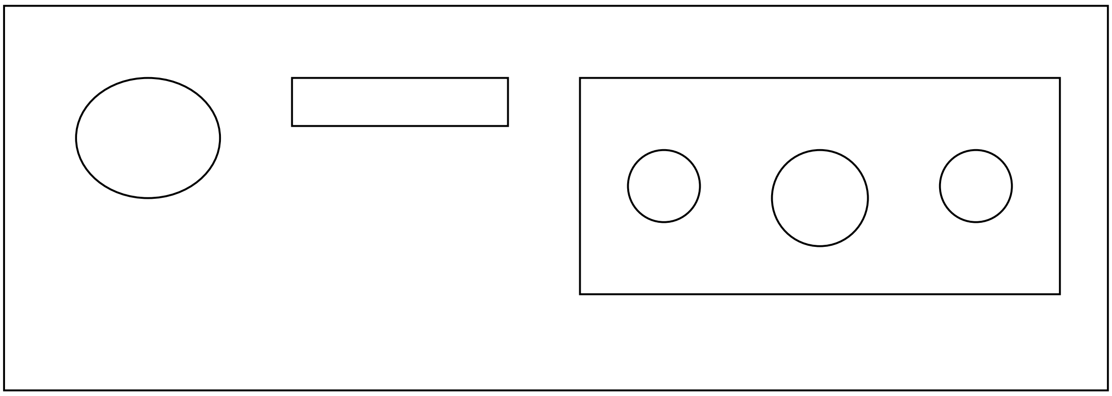
iii. In the CELL CONSTANT position, the display indicates the cell constant at which the instrument has been set.

Range Switch **:** This switch is used for selecting one of the 5 ranges of TDS.

Cell Constant **:** This control is used to set the instrument as per actual cell constant of the TDS cell. Bring the function switch at cell constant position and with the help of the constant knob, bring the reading to the actual value of the TDS cell in use.

Temperature **:** With this control, the temperature compensation between 0-50^{o}C can be adjusted.

Front view of the instrument:



Back Panel Controls:

ON/OFF : This is used to ON or OFF the instrument.

CAL Control : This potentiometer is used to adjust the display to 1000 when the function switch is at check position.

Input Connection :Two banana sockets are the input of the instrument. The TDS cell lead fitted with banana plug is these sockets for connecting the TDS cell to the instrument.

Fuse : 100Ma fuse is used to control the current from the power supply to the instrument.

Connection of the TDS Cell:

a. The TDS cell thoroughly with distilled was washed.
b. The TDS cell leads to the input sockets at the back of the instrument was filled.

Description of the procedure: To measure the TDS of any solution following under mentioned steps:

i. The cell was rinsed was solution whose TDS value is to be determined.
ii. The TDS cell was dipped in the solution under test.
iii. The function switch was set to ‘CHECK’ position.
iv. Display must read 1.000(respective of the decimal).If it dose not be so then adjust to 1.000 by rotating the CAL control provided at the back.
v. The function switches to was set Cell Constant position.
vi. The cell constant value of the TDS cell was set by Cell Constant control.
vii. The temperature control was set to the actual temperature of the solution.
viii. Now the range switch was set at position where maximum resolution is obtained.
ix. The display was read. This is the exact value of TDS at 25^0C.

5.5Water Quality Index:-

Good water quality is important for a healthy aquaculture and ecosystem. There are some basic conditions that must be met for aquatic life to live in pond waters. If these conditions are not met the criteria, aquatic species become stressed and can even die. The measurement of WQI varies from region to region and from one theory to another and mostly depends on the number and type of parameter used to develop WQI. In developing WQI for river, ponds lakes, several parameters are needed to be assessed. Since that DOE formula for determining WQI uses six parameters (DO, BOD, COD, AN, SS, pH) whereas Weighted Arithmetic Index method, use several number of parameters be used.
In this study consider both type of Index consider evaluating the actual water quality condition of the sample water. In case of DOE formula, the sub-indices are required.

$WQI= 0.22 \times SI_{DO} + 0.19 \times SI_{BOD} +0.16 \times SI_{COD}$
$+ 0.15 \times SI_{AN} + 0.16 \times SI_{SS} + 0.12 \times SI_{pH}$. .....(1)

Where, WQI = water quality index,
SI_{DO} = sub-index of DO,
SI_{BOD} = sub-index of BOD,
SI_{COD} = sub-index of COD,
SI_{AN} = sub-index of AN,
SI_{SS} = sub-index of TSS,
SI_{pH} = sub-index of pH.

Sub-indexes of water quality parameters were calculated for each water sample from the use of the following best-fit equations (Eq 2 to 7).

$$SI_{DO} = \left\{ \begin{array}{ll} 0 & \text{for } DO < 8 \\ 100 & \text{for } DO > 92 \\ -0.395 + 0.030DO^2 - 0.00020DO^3 & \text{for } 8 < DO < 92 \end{array} \right\} \quad \text{.........................(2)}$$

$$SI_{BOD} = \left\{ \begin{array}{ll} 100.4 - 4.23BOD & \text{for } BOD < 5 \\ 108e^{-0.055BOD} - 0.1BOD & \text{for } BOD > 5 \end{array} \right\} \quad \text{..........................(3)}$$

$$SI_{COD} = \left\{ \begin{array}{ll} -1.33COD + 99.1 & \text{for } COD < 20 \\ 103e^{-0.0157COD} - 0.04COD & \text{for } COD > 20 \end{array} \right\} \quad \text{.......................(4)}$$

$$SI_{AN} = \left\{ \begin{array}{ll} 100.5 - 105AN & \text{for } AN < 0.3 \\ 94e^{-0.573AN} - 5|AN - 2| & \text{for } 0.3 < AN < 4 \\ 0 & \text{for } AN > 4 \end{array} \right\} \quad \text{........................(5)}$$

$$SI_{SS} = \begin{cases} 97.5e^{-0.00676SS} + 0.05SS & \text{for } SS < 100 \\ 71e^{-0.0016SS} - 0.015SS & \text{for } 100 < SS < 1000 \\ 0 & \text{for } SS > 1000 \end{cases} \quad \text{........................(6)}$$

$$SI_{pH} = \begin{cases} 17.2 - 17.2pH + 5.02pH^2 & \text{for } pH < 5.5 \\ -242 + 95.5pH - 6.67pH^2 & \text{for } 5.5 < pH < 7 \\ -181 + 82.4pH - 6.05pH^2 & \text{for } 7 < pH < 8.75 \\ 536 - 77.0pH + 2.76pH^2 & \text{for } pH > 8.75 \end{cases} \quad \text{......................(7)}$$

Table 2: National Water Quality Standards (NWQS) for Malaysia.

	CLASS						
Parameters	Unit	I	IIA	IIB	III	IV	V
pH	mg/L	6.5-8.5	6.0-9.0	6.0-9.0	5.0-9.0	5.0-9.0	-
DO	mg/L	7	5.0-7.0	5.0-7.0	3.0-5.0	<3	<1
BOD	mg/L	1	3	3	6	12	>12
COD	mg/L	10	25	25	50	100	>100
SS	mg/L	25	50	50	150	300	300
AN	mg/L	0.1	0.3	0.3	0.9	2.7	>2.7

Where,

Class I	Conservation of natural environment; Water supply I – Practically no treatment necessary; Fishery I – Very sensitive aquatic species;
Class IIA	Water supply II – Conventional treatment required; Fishery II – Sensitive aquatic species;
Class IIB	Recreational use with body contact;
Class III	Water supply III – Extensive treatment required; Fishery III – Common of economic value and tolerant species;
Class IV	Irrigation;
Class V	None of the above

Another method is Weighted Arithmetic Index method, which was originally proposed by Horton (1965) and developed by Brown et al (1972) in the following form:

$WQI = \Sigma Q_i W_i / \Sigma W_i$ .... (8)

And $Qi = 100 \{(Va-Vi)/(Vs-Vi)\}$ .... (9)

Where, Va = actual value of the water quality parameter obtained from laboratory analysis.

Vi = Ideal value of the water quality parameter can be obtained from the standard tables. Here the ideal values (Vi) are taken as zero except pH and DO. For pH, the ideal value is 7.0 and for DO, the ideal value is 14.6 mg/l.

Vs = recommended standard value of i th parameter.

The unit weight for each water quality parameter is calculated by a value inversely proportional to recommended standard (Vs) for the corresponding parameter using the following expression.

$$W_i = K / V_s \text{ ....} \quad (10)$$

Wi is Unit weight of factor and K is proportionality constant.

Table 3 shows a classification of water quality, based on its quality index due to Brown et al (1972), Chatterji and Raziuddin (2002) etc.

Table 3: Classification of water quality based on weighted arithmetic WQI method

WQI	Status
0-25	Excellent
26-50	Good
51-75	Poor
76-100	Very Poor
Above 100	Unsuitable for Use

Chapter -6

Result & Discussion

6.1 Results:

Results of analyses of various physico-chemical parameters of pond water as (GPS-1&2) and canal water (GPS-3&4) are given in chart 2 to 15. The averages of six months data of river as well as aquaculture pond waters are presented in Table 4.

Error! Reference source not found.– Water Quality Parameters at four sampling sites in Kharibari, West Bengal

Parameter	Kholdanga Ponds GPS-1	Pranab Pukur GPS-2	Haroa Khal Outlet GPS-3	Haroa Khal Inlet GPS-4
Temperature, °C	27.8	27.5	27.1	26.9
pH value	7.88	8.0	7.66	7.51
Conductivity at 25°C, µmhos/cm	1820.0	4690.0	1215.0	1200.0
Total Dissolve Solids, mg/L	1238.0	3188.0	778.0	768.0
Calcium, mg/L	66.0	134.0	79.0	79.0
Dissolve Oxygen, mg/L	3.20	3.8	4.2	4.60
COD, mg/L	157.0	88.0	49.0	59.0
BOD at 27°C, mg/L	73.0	25.0	13.0	17.0
Nitrate, mg/l	3.67	1.2	0.53	0.84
Phosphate, mg/L	3.43	1.5	3.13	10.10
Ammonia, mg/L	12.0	11.0	14.0	26.0
Total colliform, MPN/100ml	1300000	17000.0	49000.0	940000
Fecal colliform, MPN/100ml	490000	2600.0	22000.0	700000
Magnesium, mg/L	31.0	38.0	12.0	35.0

6.2 Statistical Analysis:-

Statistical analyses were performed with Microsoft Excel (2007) software variations in four different sites of each parameter.

Water temperature of aquaculture ponds ranged from a low of 26.9°C to a high of 27.8°C varies place to place. The temperature of canal water is comparatively low from pond water. The mean temperature of the sample water is 27.325 ± 0.349 °C (Table 4). A minor variation of temperature was observed in all the sites irrespective of the canal and aquaculture pond water (Chart 2).

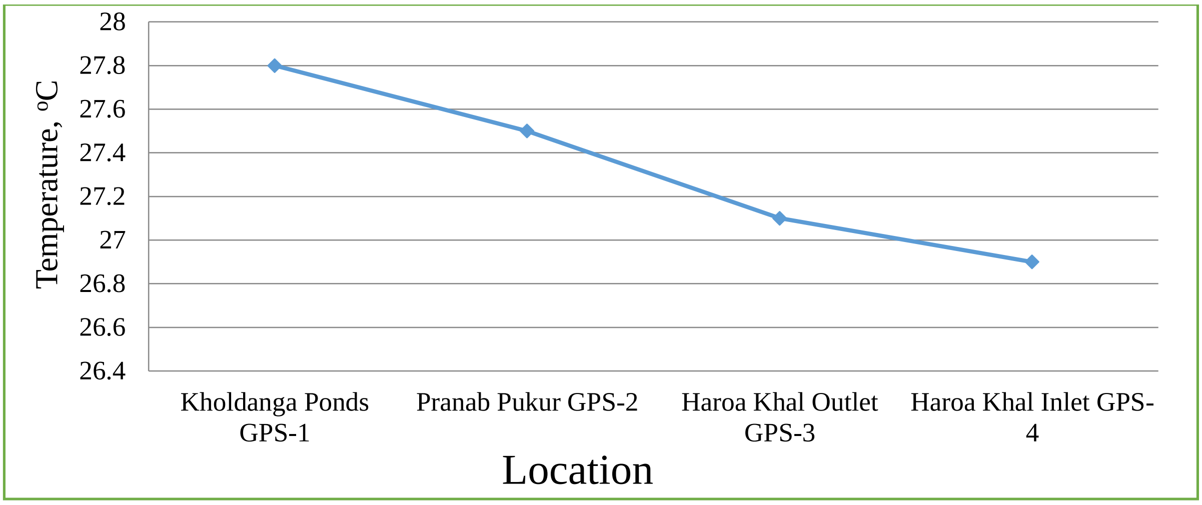


Chart 2: Site wise temperature variation.

The value of pH of aquaculture ponds were ranged between 7.51 (Haroa Khal Inlet) to 8.0 (Pranab Pukur) during the study period. On the other hand pH of canal water varies from 7.51 (Haroa Khal Inlet) to 7.66 (Haroa Khal Outlet) (Table 4). There was a minor variation of pH observed in all the sites during investigation (Chart 3). The difference between maximum value and minimum value is about 0.49. The mean pH value of the sample water is 7.763 ± 0.190.

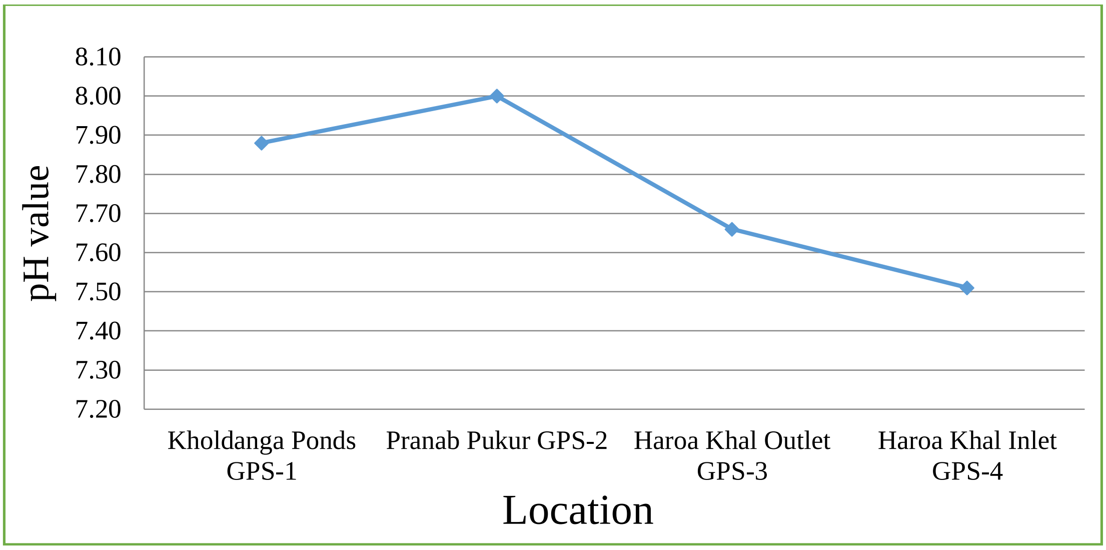


Chart 3: pH value variation site wise.

Conductivity values of aquaculture ponds at four different sites varied greatly during this investigation. The conductivity was found maximum in Pranab pukur ponds i.e. 4690 µmhos/cm and minimum in Haroa Khal Inlet i.e. 1200 µmhos/cm. The conductivity values in canal water found lower values i.e.1207.5 µmhos/cm (mean value) in comparison of pond water i.e. 3255 µmhos/cm (mean value). The variation of conductivity site wise shown in chart (Chart 4). The mean value of conductivity of the sample water is 2231.25 ± 1441.425 µmhos/cm.

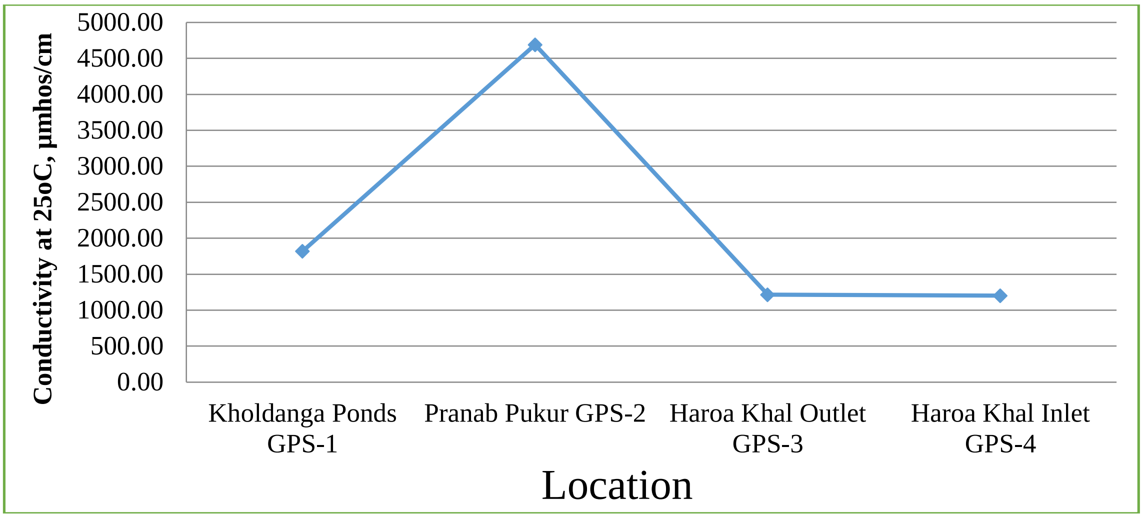


Chart 4: Conductivity variation of site wise.

The value of Total dissolved solid showed high and low value at Pranab pukur and Haroa khal inlet respectively. The mean value of total dissolved solid in canal water was 773 mg/L and pond water was 2213 mg/L (Table 4). The total dissolved solid among the sites showed a wide range of variation (Chart 5). The mean value of Total Dissolve Solids of the sample water is 1493 ± 996.858 mg/L.

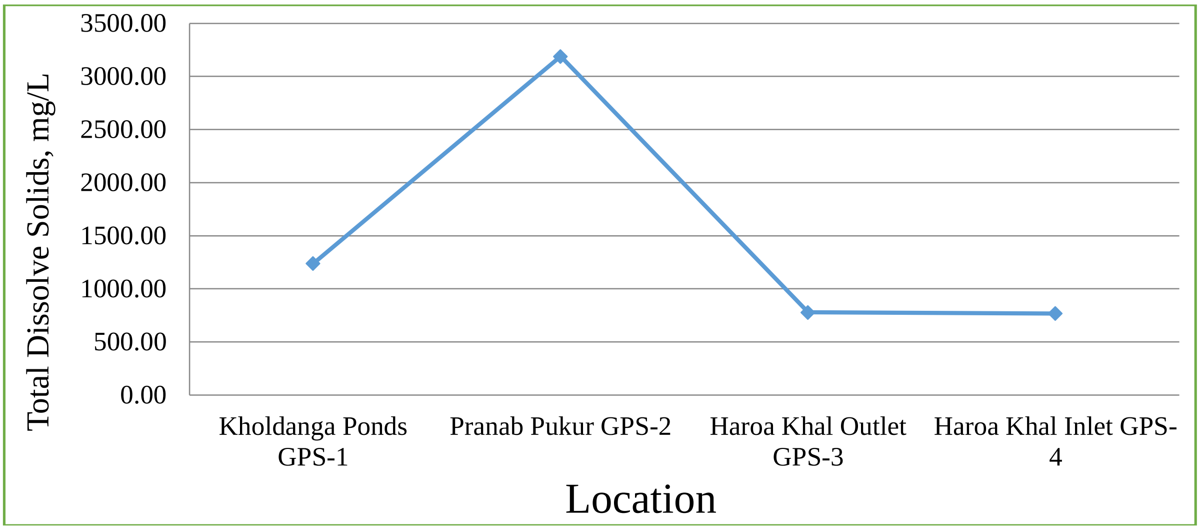


Chart 5: Site wise variation of Total Dissolve Solids.

Calcium content is same both canal water inlet and outlet i.e. 79.0 mg/L and more difference in pond water i.e. 66.0 mg/L to 134.0 mg/L (Table 4). The maximum value of Calcium content was observed in Pranab pukur which near to the outlet of canal but canal water shows low concentration of Calcium (Ca). The average value of calcium of pond water was 100 mg/L (Table 1). The variation of calcium in different site showed in the chart (Chart 6). The mean value of Calcium content of the sample water is 89.5 ± 26.235 mg/L (Table 4).

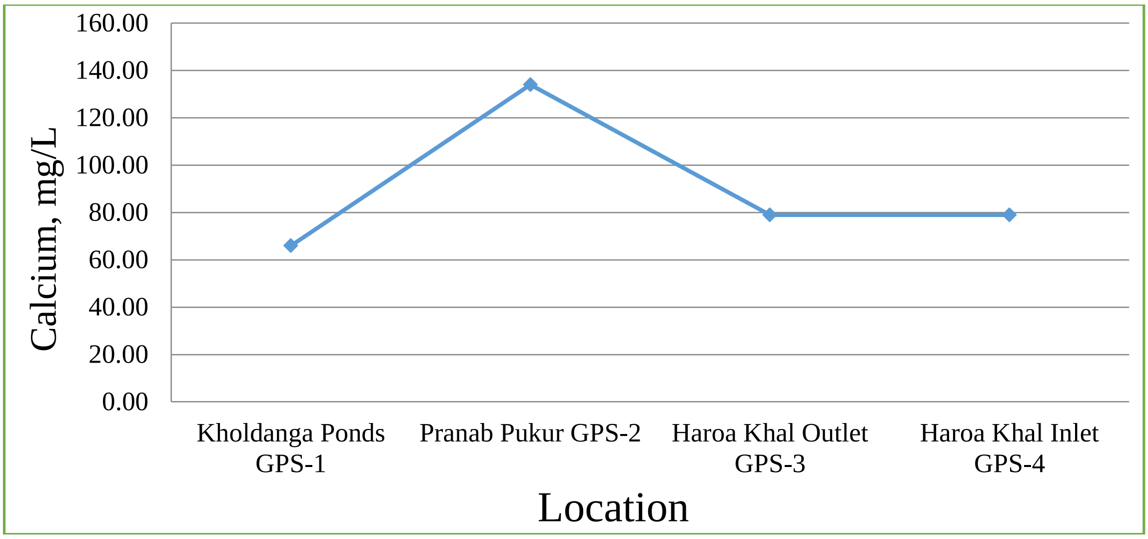


Chart 6: Site wise variation of Calcium content.

The maximum value of dissolved oxygen concentration was observed in Haroa Khal inlet i.e. 4.60 mg/L where as the minimum value of dissolved oxygen was found in Kholdanga Pond i.e. 3.20 mg/L. The average value of dissolved oxygen of sample water was 3.95 mg/L (Table 2). The dissolved oxygen value more on difference Kholdanga pond and Haroa khal inlet (Chart 7). The mean value of Dissolve Oxygen of the sample water is 3.95 ± 0.517 mg/L (Table 4).

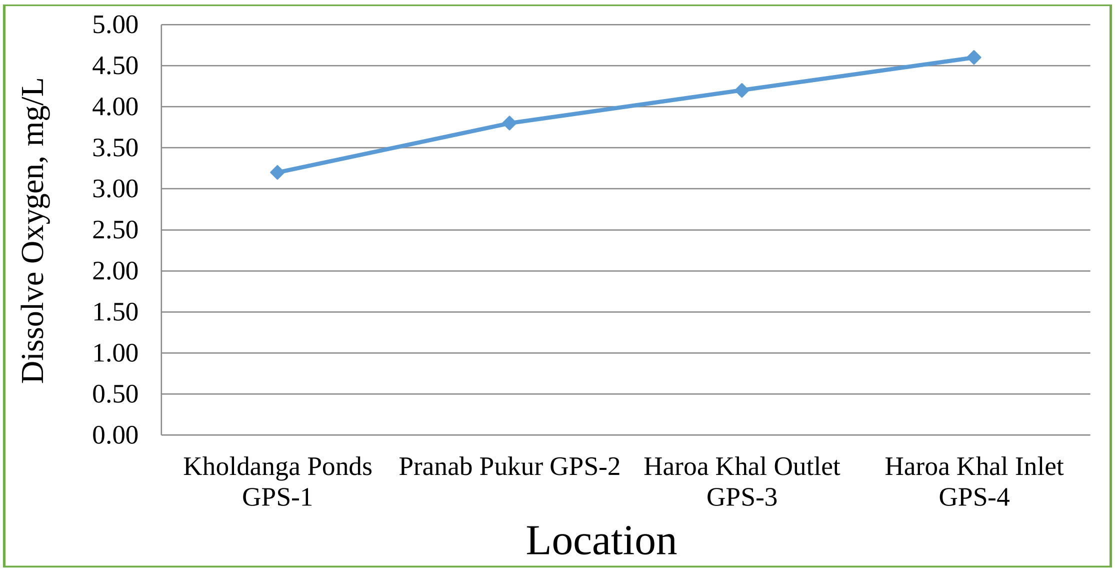


Chart 7: Site wise variation of Dissolve Oxygen.

The value of Chemical Oxygen Demand was observed, highest in Kholdanga Pond i.e. 157.0 mg/L and lowest in Haroa Khal outlet i.e. 49.0 mg/L. There was a significant variation between two sites, almost triple. The average value of Chemical Oxygen Demand of sample water was 88.25 ± 42.198 mg/L (Table 4). The variation of COD is shown in the chart (Chart 8).

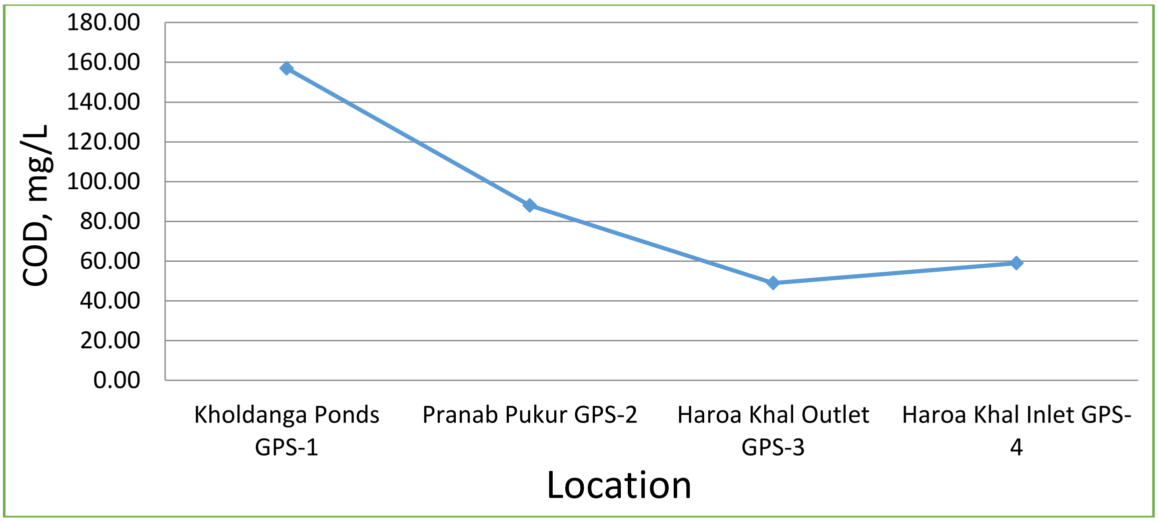


Chart 8: Site wise variation of Chemical Oxygen Demand

The value of Bio-chemical Oxygen Demand was observed, maximum in Kholdanga Pond i.e. 73.0 mg/L and minimum in Haroa Khal outlet i.e. 13.0 mg/L. There was a significant variation between two sites. The average value of Bio-chemical Oxygen Demand of sample water was 32 ± 24.062 mg/L (Table 4). The variation of BOD is shown in the chart (Chart 9).

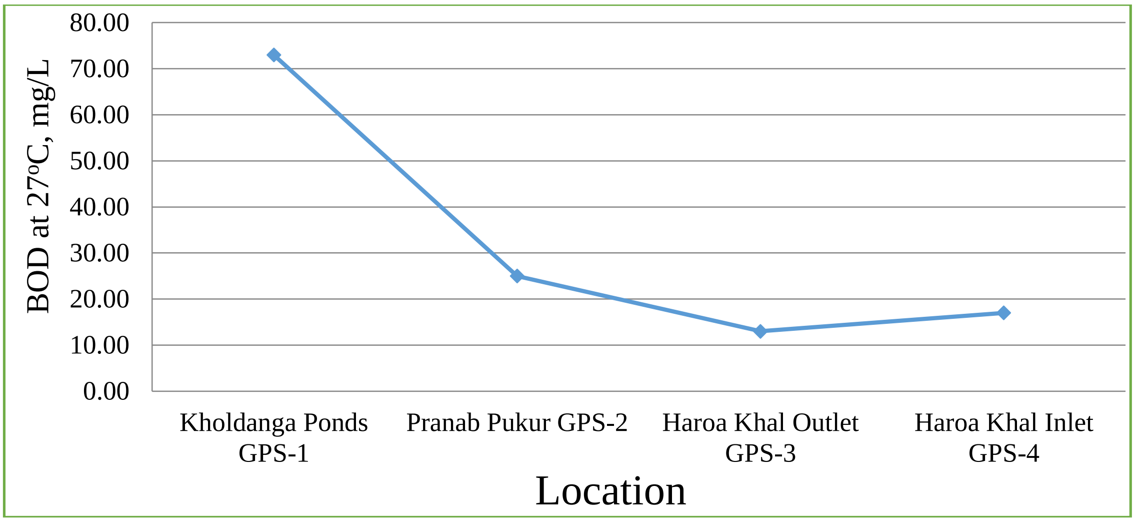


Chart9: Site wise variation of Bio-chemical Oxygen Demand.

Nitrate content of all the aquaculture sites along with canal water showed the variation on site basis in the chart (Chart 10). The lower Nitrate concentration found in the canal outlet i.e. 0.53mg/L and comparatively higher nitrate concentration found in Kholdanga pond site i.e. 3.67mg/L. The average value of nitrate among the sample water was 1.57 ± 1.238 mg/L (Table 4).

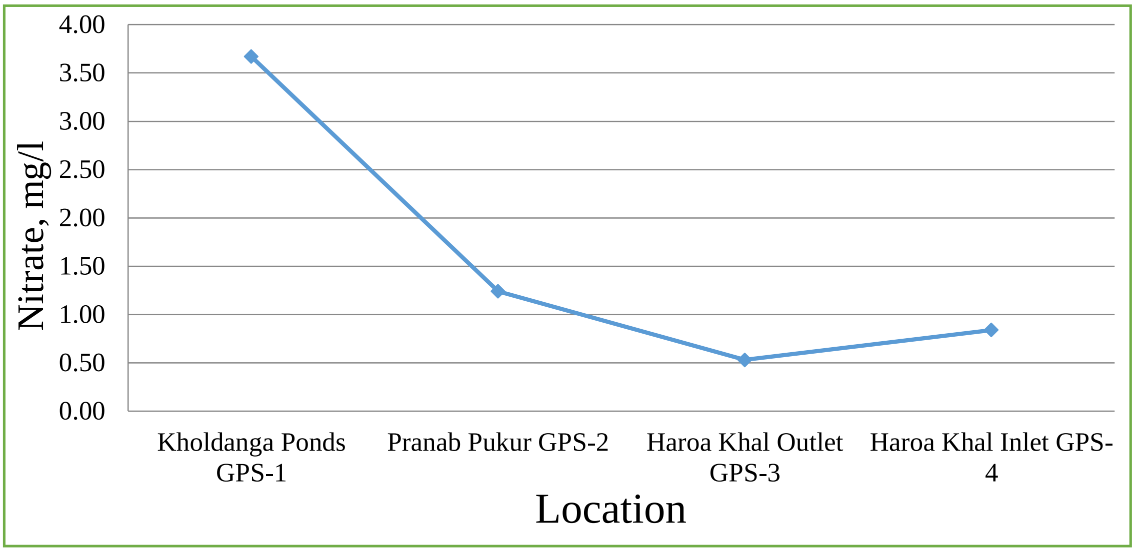


Chart10: Site wise variation of Nitrate content (NO_3).

Among the aquaculture ponds phosphate content was found to be highest i.e. 10.10 mg/L in site Haroa khal inlet where as the lowest value i.e. 1.5 mg/L was observed in Pranab pukur as shown in Table 4. The Phosphate content in Haroa khal is significantly varies inlet to outlet and the difference between canal outlet and Pranab pukur site is more however these two sites was too close. The variation of Phosphate content Shown in the chart (Chart 11). The mean value of phosphate in sample water is 4.547 ± 3.286 mg/L (Table 4).

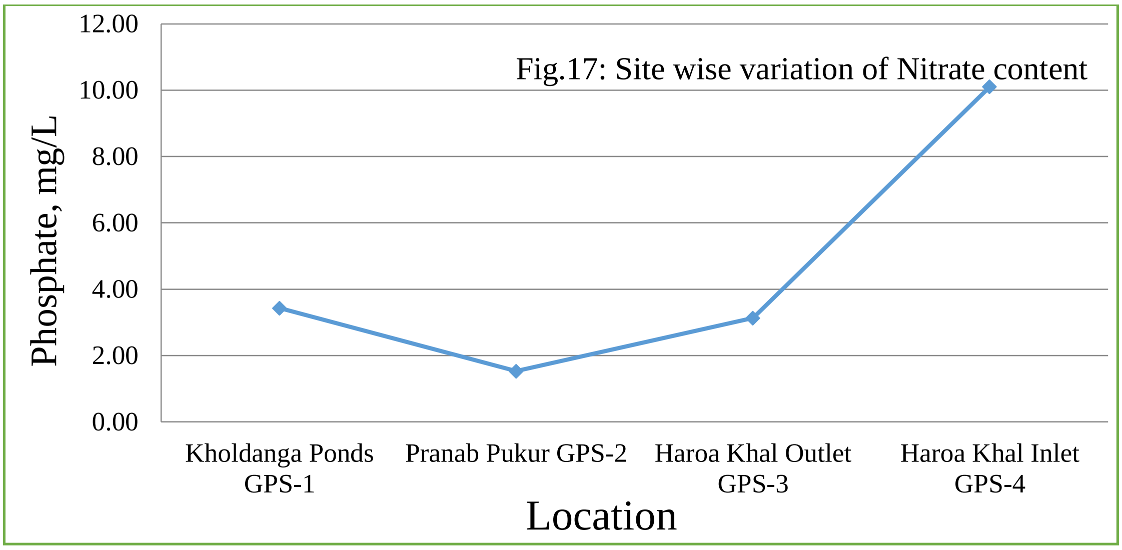


Chart11: Site wise variation of Phosphate content.

The value of Ammonia (Ammonical-N) was observed, maximum in Haroa Khal inlet i.e. 26.0 mg/L and minimum in Pranab pukur i.e. 11.0 mg/L. There was a variation between canal inlet and outlet is too high. The average value of Ammonia of sample water was 15.75 ± 6.016 mg/L (Table 4). The variation of Ammonia is shown in the chart (Chart 12).

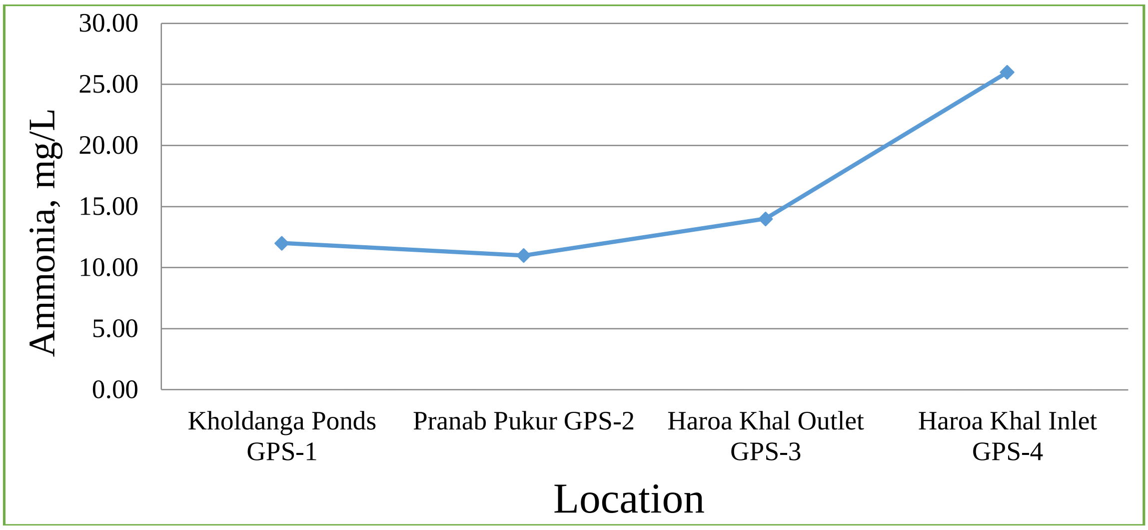


Chart12: Site wise variation of Amonia content.

Total colliform of aquaculture pond ranged from a low of 17000 MPN/100ml in Pranab pukur to a high of 1300000 MPN/100ml in Kholdanga Pond. There was a huge variation of Total colliform was observed in allsites canal water and aquaculture pond water (Chart 13). The average value of total colliform among the sites is 576500 ± 558319.13 MPN/100ml (Table 4).

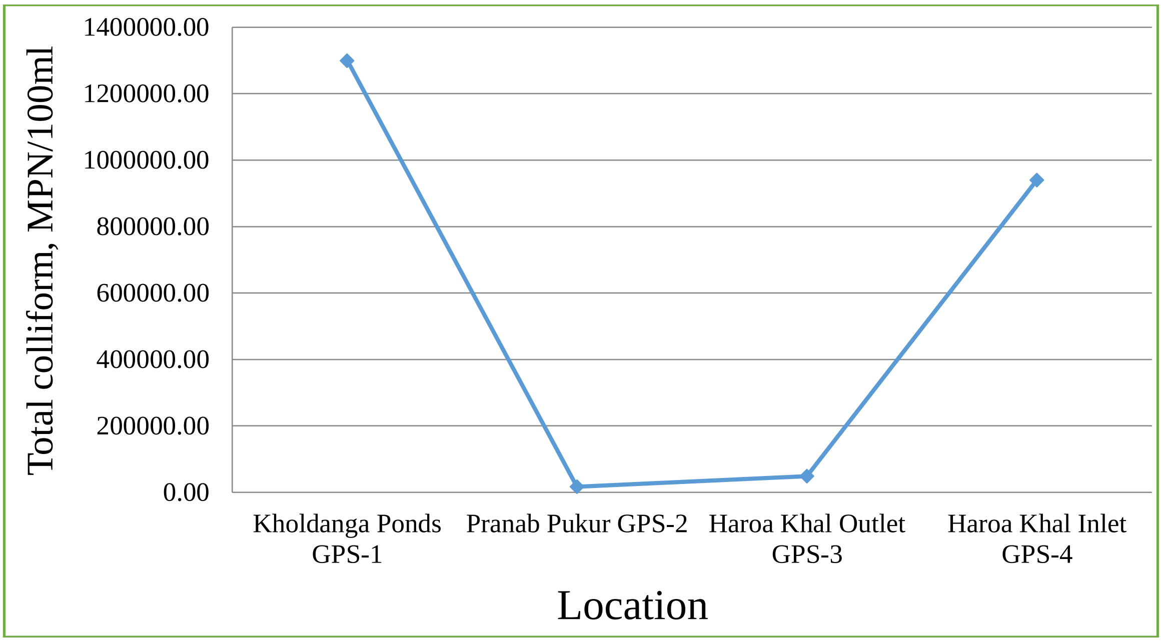


Chart13: Site wise variation of Total Colliform content (MPN/100ml)

In case of Fecal colliform, the maximum value observed in Haroa khal i.e. 700000 MPN/100ml and minimum value found in Pranab pukur site i.e. 2600 MPN/100ml (Table 4). The variation of fecal colliform shown in the chart (Chart 14). The mean value of the fecal colliform calculated is 303650 ± 300739.7 MPN/100ml.

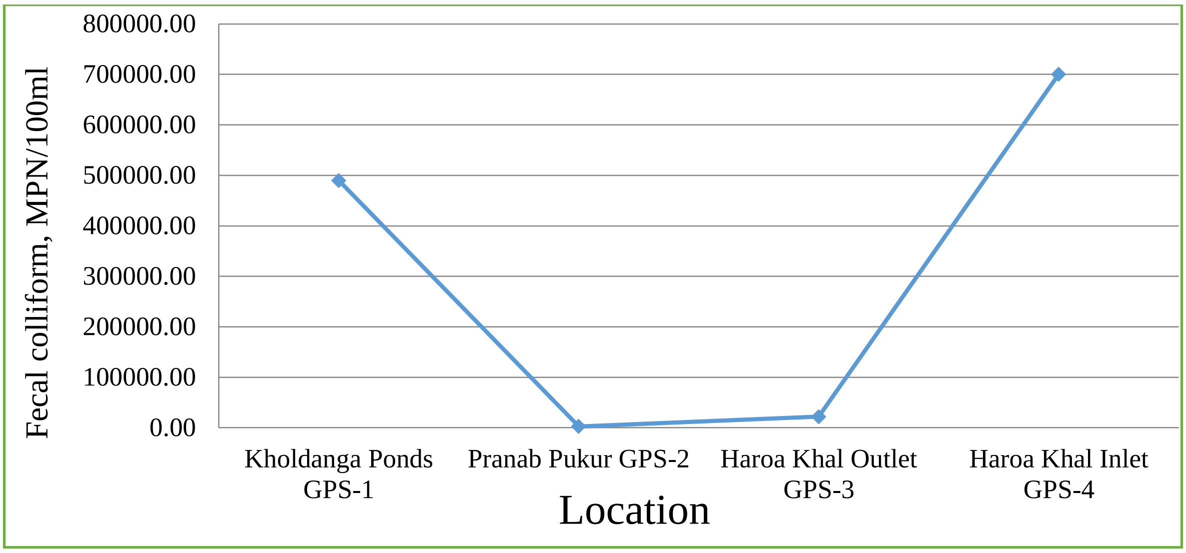


Chart 14: Site wise variation of Fecal Colliform content (MPN/100ml)

Magnesium content recorded maximum values in Pranab pukur site i.e. 38.0 mg/L where as the minimum value in Haroa khal site 12.0 mg/L (Table 4). The average value of magnesium was 29 ± 10.124 mg/L (calculated from table 4). The variation of magnisium content shown in the chart (Chart 15).

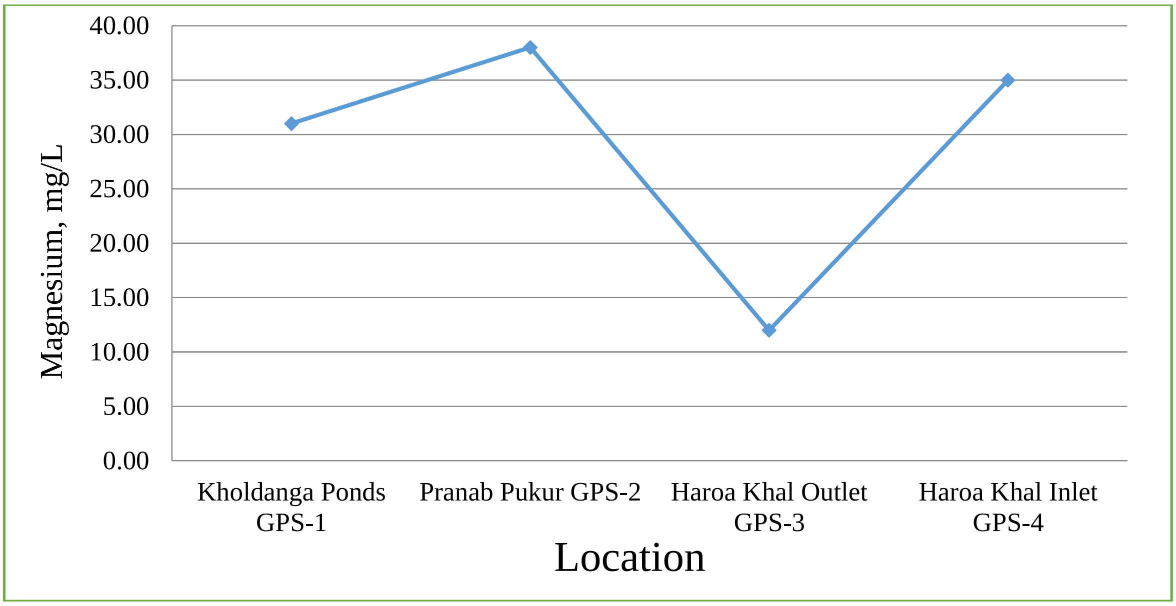


Chart 15: Site wise variation of Magnesium content

Calculation shown in table-5 in respect of weighted arithmetic WQI method in Kholdanga pond. The WQI found for this pond is 442.569.

Table 5 – Water Quality Index calculation for Kholdanga Ponds as per weighted arithmetic WQI method

Parameter	Kholdanga Ponds GPS-1	Standard values (Vs)	Qi	Wi	Wi x Qi
pH value	7.880	7.500	176.000	0.281	49.485
Conductivity at 25oc, µmhos/cm	1820.000	300.000	606.667	0.007	4.264
Total Dissolve Solids, mg/L	1238.000	500.000	247.600	0.004	1.044
Calcium, mg/L	66.000	75.000	88.000	0.028	2.474
Dissolve Oxygen, mg/L	3.200	6.000	132.558	0.351	46.588
COD, mg/L	157.000	10.000	1570.000	0.211	331.068
Nitrate, mg/l	3.670	45.000	8.156	0.047	0.382
Magnesium, mg/L	31.000	30.000	103.333	0.070	7.263
				1.00	**442.569**

Calculation shown in table-6 in respect of weighted arithmetic WQI method in Pranab Pukur. The WQI found for this pond is 313.669.

Table 6: Water Quality Index calculation for Pranab Pukur as per weighted arithmetic WQI method.

Parameter	Pranab Pukur GPS-2	Standard values (Vs)	Qi	Wi	Wi x Qi
pH value	8.000	7.500	200.000	0.281	56.232
Conductivity at 25oc, µmhos/cm	4690.000	300.000	1563.333	0.007	10.989
Total Dissolve Solids, mg/L	3188.000	500.000	637.600	0.004	2.689
Calcium, mg/L	134.000	75.000	178.667	0.028	5.023
Dissolve Oxygen, mg/L	3.800	6.000	125.581	0.351	44.136
COD, mg/L	88.000	10.000	880.000	0.211	185.567
Nitrate, mg/l	1.240	45.000	2.756	0.047	0.129
Magnesium, mg/L	38.000	30.000	126.667	0.070	8.903
				1.00	**313.669**

Calculation shown in table-7 in respect of weighted arithmetic WQI method in Haroa Khal outlet. The WQI found for this pond is 192.273.

Table 7: Water Quality Index calculation for Haroa Khal Outlet as per weighted arithmetic WQI method.

Parameter	Haroa Khal Outlet GPS-3	Standard values (Vs)	Qi GPS-3	Wi	Wi*Qi GPS-3
pH value	7.660	7.500	132.000	0.281	37.113
Conductivity at 25oc, µmhos/cm	1215.000	300.000	405.000	0.007	2.847
Total Dissolve Solids, mg/L	778.000	500.000	155.600	0.004	0.656
Calcium, mg/L	79.000	75.000	105.333	0.028	2.962
Dissolve Oxygen, mg/L	4.200	6.000	120.930	0.351	42.501
COD, mg/L	49.000	10.000	490.000	0.211	103.327
Nitrate, mg/l	0.530	45.000	1.178	0.047	0.055
Magnesium, mg/L	12.000	30.000	40.000	0.070	2.812
				1.00	**192.273**

Calculation shown in table-8 in respect of weighted arithmetic WQI method in Haroa khal Inlet. The WQI found for this pond is 208.668.

Table 8: Water Quality Index calculation for Haroa khal Inlet as per weighted arithmetic WQI method.

Parameter	Haroa Khal Inlet GPS-4	Standard values (Vs)	Qi GPS-4	Wi	Wi*Qi GPS-4
pH value	7.510	7.500	102.000	0.281	28.679
Conductivity at 25oc, µmhos/cm	1200.000	300.000	400.000	0.007	2.812
Total Dissolve Solids, mg/L	768.000	500.000	153.600	0.004	0.648
Calcium, mg/L	79.000	75.000	105.333	0.028	2.962
Dissolve Oxygen, mg/L	4.600	6.000	116.279	0.351	40.867
COD, mg/L	59.000	10.000	590.000	0.211	124.414
Nitrate, mg/l	0.840	45.000	1.867	0.047	0.087
Magnesium, mg/L	35.000	30.000	116.667	0.070	8.201
				1.00	**208.668**

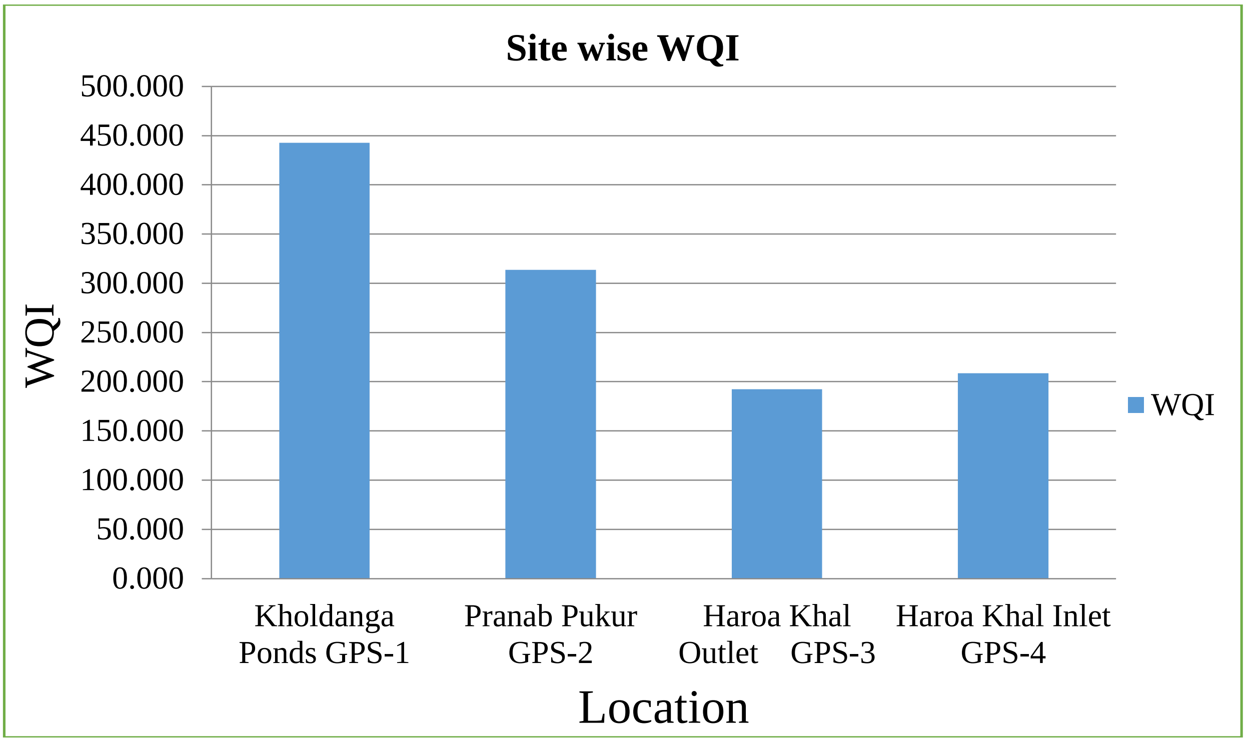


Chart 16: Site wise WQI value as per weighted arithmetic WQI method.

Calculation shown in table-8 in respect of Water Quality Index calculation as per DOE- WQI method. The DOE WQI found as 12.496, 22.868, 33.973, 30.326 at the sie of Kholdanga Ponds, Pranab Pukur, Haroa Khal Outlet, Haroa Khal Inlet respectively.

Table 9: Water Quality Index calculation as per DOE- WQI method.

Site/Sub Index	Kholdanga Ponds GPS-1	Pranab Pukur GPS-2	Haroa Khal Outlet GPS-3	Haroa Khal Inlet GPS-4
S_{DO}	0.000	0.000	0.000	0.000
S_{BOD}	-5.351	24.807	51.533	40.699
S_{COD}	2.477	22.351	45.764	38.430
S_{AN}	0.000	0.000	0.000	0.000
S_{pH}	92.641	91.000	95.197	96.603
S_{SS}	ND	ND	ND	ND
WQI	**12.496**	**22.868**	**33.973**	**30.326**

ND = Not Detectable.

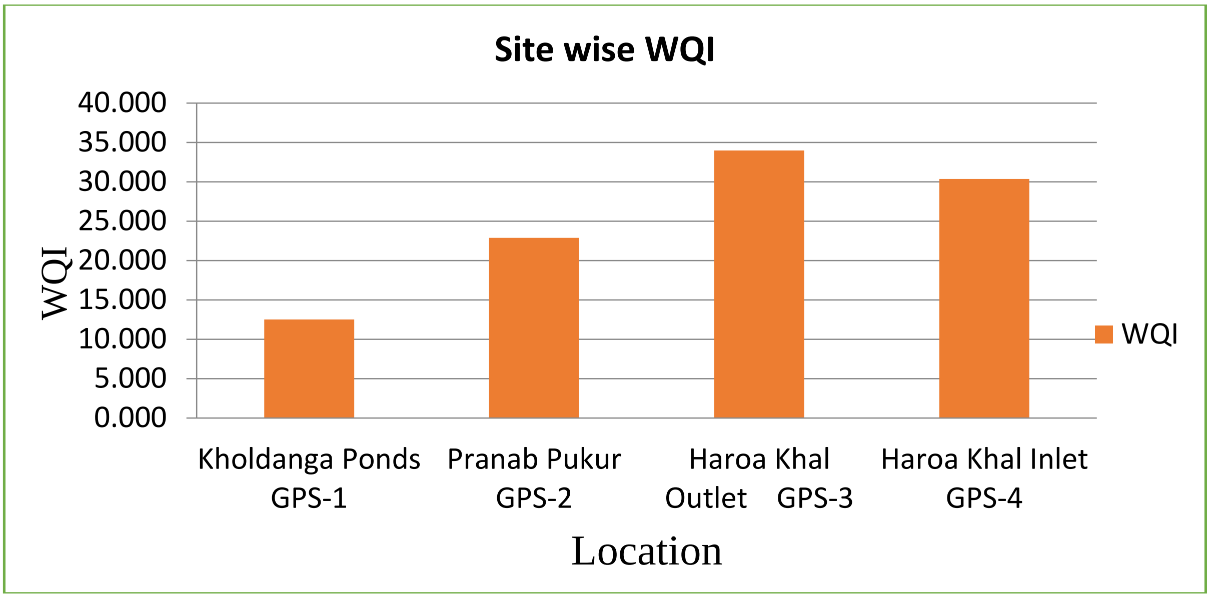


Chart 17: Site wise WQI value as per DOE WQI method.

6.3 Discussion:

The result of physico-chemical parameters of aquaculture ponds were compared with the pre-scribed water quality standard as per ICAR-Indian Institute of Water Management and Water quality guidelines for the management of pond fish culture by Anita Bhatnagar, International Journal of Environmental Sciences Volume 3, No 6, 2013.

The water temperature found in between 26.9°C to 27.8°C. Bhatnagar et al. (2013) suggested the range of temperature as 28-320C good for tropical major carps and 25-30^0C is ideal for Penaeous monodon culture. As per Santhosh and Singh (2007), water temperature between 24 and 30^0C suitable for carp culture. So, the temperature fulfils the criteria.

The pH of the aquaculture pond water samples found in between 7.51 to 8.0. The pH of fish blood is near about 7.4, generally pH between 7 to 8.5 is ideal for biological productivity. According to Santhosh and Singh (2007) the pH range suitable for fish culture is between 6.7 and 9.5 and ideal pH level is 7.5 to 8.5 and beyond this limit, it's stressful to the fishes. Then the water quality of the study area is very suitable for aquaculture.

The electrical conductivity of sample water at 25°C found between 1200 and 1820 µmhos/cm. The optimum conductivity for fish production varies from one species to another. Stone and Thomforde (2004) recommended the desirable range of conductivity 100-2,000 mSiemens/cm and acceptable range 30-5,000 mSiemens/cm for pond fish culture. It seems that the range of conductivity satisfied the existing water condition.

In this study it seems that in most of the sites, aquaculture ponds have higher value of total dissolved solid than canal water. Total dissolved solids shows more value in aquaculture ponds may be due to sedimentation of unused agrochemicals, food additives, and excreta.

The calcium (Ca^{++}) and magnesium (Mg^{++}) content in sample water found between 66 to 134 mg/L and 12 to 38 mg/L respectively. According to Wurts and Durborow (1992) , recommended range for free calcium in culture waters is 25 to 100 mg L-1 (63 to 250 mg L-1 CaCO3 hardness). It shows that the calcium and magnesium limit is under the desirable limit. This limit depend on the season basis and site basis, type of fish culture, sample collection time etc.

In the next phase, water quality analysis completely based on determination of WQI. These two types of WQI are discussed on their criteria.

In case of WAI, water quality Index obtained in this study period between 442.569 and 192.273 (Table 5 to 8) respectively. The water quality Index value 442.569 indicates the unsuitable for aquaculture and WQI 192.273 and 208.668 is considerable for aquaculture but not for drinking. So, Pranab pukur pond and ponds near Haroa khal is considerable for Aquaculture.

As per reference of Naubi I., et al, in respect of DOE WQI, the WQI for Kholdanga ponds indicate the level water is Class V which is not suitable for fisharies as well as aquaculture, WQI for Pranab pukur classified as IV which is usable for agricultural purpose but not suitable for drinking, its quality tolerable for livestock drinking, aquaculture. Next the WQI for Haroa khal Outlet is met as Class III (except BOD and Ammonia content), its normal for aquaculture and economical use for fish culture. It seen that Haroa khal inlet water quality as per DOE WQI, same as Haroa khal inlet and classified as III (except high ammonia value) indicate that this water can be use for aquaculture.

Chapter -7

Conclusions and Recommendations

7.1 Conclusion:

During the study, it is observed that the water quality of Kholdanga pond for aquaculture purpose in study period become unsuitable. We recommended that the water is not fit for drinking purpose as well as aquaculture purpose without treatment. The Study show that the water of the Kholdanga pond deteriorated badly due to wastage of previous cultivation.Its bacteriological activity very high, anthropogenic activities like washing, Bathing etc. Therefore an urgent effort must be taken to develop ecosystem based management strategies with the help of scientists, resource managers, policy makers, government and non-government organizations, and environmentalist carefully taken a step for better future. The other ponds condition is moderate not too good in position except Haroa khal outlet.

7.2 Future Scope :

By 2024-25, the production of annual growth 220 lakh MT at an annual average growth rate about 9%. In COVID-2019 pandemic, India achived all time high export of marine product about 7000million USD from april 2021 to 2022. ‘Pradhan Mantri Matsya Sampada Yojana (PMMSY)’ to bring about ‘Blue Revolution’ through sustainable and responsible development of fisheries sector in India. This scheme aims to double the export earnings to Rs.1,00,000 crore and generate about 55 lakhs direct and indirect employment opportunities in fisheries sector over a period of next five years.

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