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Case Study of Deterioration of Mansar Lake and Comparative Study of FAB and SBR Technologies in Sewage Treatment Plant

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Abstract:
The deterioration of Mansar Lake, a significant tourist attraction and a vital water resource in India, has become a matter of concern due to the discharge of untreated sewage and industrial effluents. The present study aims to investigate the factors leading to the degradation of Mansar Lake and the effectiveness of two advanced sewage treatment technologies, Fixed Activated Beds (FAB) and Sequencing Batch Reactors (SBR), in treating sewage waste.
The study begins with a comprehensive analysis of the factors contributing to the degradation of Mansar Lake, including the inflow of untreated sewage, industrial effluents, and agricultural runoff, as well as the impact of climate change and anthropogenic activities. The research then moves on to the comparative study of FAB and SBR technologies, evaluating their performance in terms of pollutant removal efficiency, energy consumption, and operational costs.
The results of the study show that both FAB and SBR technologies are effective in treating sewage waste, with SBR technology having a slight edge in terms of pollutant removal efficiency. However, FAB technology is more cost-effective and energy-efficient, making it a more viable option for developing countries with limited resources.
The study concludes with recommendations for the implementation of FAB technology in the sewage treatment plant serving Mansar Lake, as well as the need for stricter regulations and enforcement to prevent the inflow of untreated sewage and industrial effluents into the lake. The study also emphasizes the importance of public awareness and education in preserving the lake's ecological balance and promoting sustainable tourism practices.
Mansar Lake, sewage treatment, FAB technology, SBR technology, pollutant removal efficiency, cost-effectiveness, energy efficiency, sustainable tourism.

CHAPTER-1
INTRODUCTION
1.1 MANSAR LAKE

Jammu is a unique tourist destination of the Indian subcontinent; One of the most important tourist attractions today is the most beautiful Mansar Lake (a large body of water) in the south of Jammu city (in the summer J&K Capital city. It is also a sacred place with good association and relationship with Manasarovar Lake. There is a Sheshnag temple on the eastern side of the lake. [1]

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Fig1.1. 2-DVIEW OF MANSAR LAKE

PHYSICAL DIMENSIONS

LOCATION		JAMMU, Jammu and Kashmir
CATCHMENT AREA		0.778 Sq.Km 0.46 Sq.Km
MAXIMUM LENGTH		1038 m (N32W-S32E) 862 m (N33W-S33E)
MAXIMUM WIDTH		644 m (N62E-S62W) 510 m (N57E-S57W)
SURFACE AREA		0.522 Sq.Km (52.2 ha) 0.29 Sq.Km.(29 ha)
AVERAGE DEPTH		666 metres above msl
MAXIMUM DEPTH		35 metres 23.20 m.
WATER VOLUME		Very High Geochemically for both lakes. Average Total Dissolved
SOLIDS		151 mg/litre (surface water) 175 mg/litre (sub-surface water).
LAKE ISLAND		1 (NNW-NNE : 90m x 18m)

1.2 MANSAR LAKE POLLUTION:

Aquatic ecosystem worldwide is biding severely altered or destroyed at a rate greater than that at any other times in human history and far faster than they are being restored. Mansar Lake ecosystem (Lat.32.696076Ã, Â°N long.75.146806Ã, Â°E) situated in the outskirts of JAMMU, the summer capital of Jammu and Jammu State is under tremendous anthropogenic pressure since more than three decades. The uniqueness of the lake is that 20,000 people live within the lake [2]. The myriad ways in which people use the lake, along with the numerous pollutant-generating activities have stressed the lake ecosystem in diverse ways. These stresses have caused significant impairment to lake quality.

Three major classes of stresses have been identified that has degraded its quality:

1. Eutrophication is caused by an overabundance of organic matter and nutrients coming from both point and non-point sources.
2. Physical and hydrological alterations.
3. Situation resulting from insufficient erosion control.

Out of these three categories, stress issues resulting from over-enrichment of nutrients and excessive plant growth are likely the most prevalent, since an estimated 12.30 x 106 m^3 of liquid waste, containing 8.17 tons of phosphorus and 5 tons of inorganic nitrogen, enriches lakes every year. Higher total dissolved solids values indicate that siltation is still occurring, that the partially operational Settling Basin is failing to retain the slit, that there is a significant amount of sewage entering the lake, and that organic waste is mineralizing.[8].

Due to insufficient sanitary systems, bad land practices in the surrounding vegetable gardens, and the direct discharge of grey wastewater, the number of bacteria has significantly increased in the ecosystem, especially in the houseboat regions and around lakes.

Large amounts of untreated sewage are dumped into lakes as a result of unplanned and rapid urbanization, which could eventually cause health issues. Sewage, which is primarily composed of nitrogen and phosphate, is an unhealthy source of nutrients that functions as a super fertilizer. This causes algae and ferns, which gradually reduce the water's oxygen content, which is essential for fish and other aquatic life. In the entire lake, eutrophication, or excessive weed growth, is common.[3].

Vast stretches of the periphery have been recovered and transformed into floating gardens. Over the past 50 years, the Mansar catchment area's expanding agricultural sector has also contributed significantly to fertilizer levels and other square kilometers. According to experts, the lake will disappear in the coming years if pollution levels don't decrease. runoff carrying agricultural pesticides. Soil erosion has been exacerbated by the lake's catchment area's rapid deforestation. Despite the tanks built by J&K Lakes and the Waterways Development Authority, over 80,000 tons of silt are deposited in the lake annually.[1].

Because there is little breeze to aerate the water and the lake drainage system is blocked, researchers refer to the area as "a Lake in Peril." Anthropogenic influences have caused the Lake to remarkably decline from 24 to 1.41.

1.3 IMPACT OF POLLUTION IN MANSAR LAKE ON THE LIVES OF PEOPLE.

Despite having lakes, streams, rivers, and mountains all around it, Jammu lacks a reliable source of pure drinking water for residential usage. Water sources throughout the valley are filthy, which contributes to an alarmingly high infant death rate of 1 in 5 attributed to common water-borne infectious illnesses. Polluted water supplies cause forty percent of all illnesses, including cholera, poliomyelitis, gastroenteritis, typhoid, and ineffectual hepatitis outbreaks.[13]

1.4. NEED OF SEWAGE TREATMENT PLANT.

With the glitz and comforts of contemporary living, growing urbanization has come at a silent but steady cost to humanity in the form of declining ecological resources. Every day, massive amounts of untreated waste water are released as industrial effluents and household sewage. These contaminate the bodies of water where they are discharged. Therefore, it is imperative to clean and recycle this waste water in order to lessen the strain on freshwater resources.[5]. Sewage treatment plants (STPS) were marketed as the lake's magic bullets after it was determined that the untreated sewage inflow was the main cause of the problem. Therefore, a significant portion of the money allocated under the Mansar conservation plan were used to build the plants and the catchment area's sewage system a few years ago. Without these STPs, it would be impossible to determine whether the cure is having the desired effect. Ideally, the effluent from a STP should have the same physiochemical properties as the recipient water body to prevent any changes to its quality. Since a large portion of the JAMMU population depends on Mansar Lake for their drinking water, extra attention is necessary. [6].

LAND USE CATEGORY OF THE LAKE	Area in Km^2
Administrative	0.00
Car Parking /Transportation	0.00
Cultivated	2.29
Educational	0.00
Graveyard /crematorium	0.00
Park /Lawn	0.03
Religious	0.00
Residential	0.66
Roads /Paths	0.07
Shikara Stand	0.00
Tourist Infrastructure	0.01
Vacant Land with or without vegetation	0.37
Waterbody with Houseboats	0.15
Waterbody with Rads /Flotating Gardens	0.35
Waterbody with submerged vegetation /Open Expanse	15.41
Waterbody with floating /emergent vegetation	0.25
Waterbody with floating emergent Vegetatin	5.01
Database: Quick Bird Imagery of January, 2007	
Total	24.60

Table 1.1 Showing land use category of Mansar lake (data from L.A.W.D.A)

OBJECTIVES

1. To evaluate the quality standards using tests for ammonia, nitrogen, total phosphorus, pH, biochemical oxygen demand, chemical oxygen demand, and nitrogen on water samples collected from Mansar Lake at the sewage treatment plants in Jammu and Samba.
2. To compare the outcomes with both the international water quality standards and the quality standards upheld by the Directorate of Tourism Jammu.
3. To determine the issues surrounding Mansar Lake.
4. To make recommendations for actions that will enhance effluent quality and lessen eutrophication in the mentioned water body.

CHAPTER-2
LITERATURE SURVEY REVIEW
LITERATURE SURVEY REVIEW:-
2.1 Hydrology of Lakes and Swamps:-
(Kumar et al., 2006;Chandrakiran and Sharma, 2013; Zubair and Ahrar, 2013)

Mansar Lake, in the Indian state of Jammu and Kashmir, is situated in the foothills of the Himalayas. A bathymetric survey and physico-chemical investigation were conducted to evaluate the water quality and quantity. According to the bathymetric study, Mansar Lake has a maximum depth of 38.25 meters, a maximum length of 1204 meters, and a maximum width of 645 meters. At the current outflow level, the lake's surface area is 0.59 × 10 meters. The lake's average width is 490 meters, its average depth is 21 meters, and its average floor slope is 0.14 meters. The lake has a storage capacity of 11.57 × 10 m up to the current outflow level. The vertical variations in temperature, pH, electrical conductivity, dissolved oxygen, hardness, and alkalinity indicate that Mansar Lake is stratified in other months and experiences complete mixing in January and February. The three most common cations are calcium, magnesium, and sodium, while the most common anion is bicarbonate. Chemical parameter analysis indicates that the lake water is of the Ca-Mg-HCO3-CO3 type. The Mansar Lake water's phosphate concentration of more than 0.03 mg·L suggested that the lake is eutrophic. Appropriate actions have been recommended for Mansar Lake's sustainable management. Tectonic, volcanic, glacial, and lagoon lakes exist in a variety of formations. The Himalayan region and the floodplains of the Indus and Brahmaputra, which are the few natural lakes, are home to the authors Li et al. (2015), Worni et al. (2013), and others. Nonetheless, have been created over millennia in India's semi-arid peninsula and peninsula.[3].

2.2 ZOOPLYNKTONS AND WATER PRODUCTIVITY OF LAKES IN JAMMU:-

(Kumar et al., 2006)

Freshwater for the Lake comes from surface runoff and underground springs. The hills that tower 700–800 meters above the lake create an evergreen canopy that is home to a wide variety of plant and animal species (Kumar and Singh, 2006). The current research location, Lake Surinsar (750 02' 30' E and 320 46' 30' N), is a charming sweet water lake that is significant because of its invaluable historical, cultural, and ecological assets.Nevertheless, the bathymetry and physico-chemical properties of Mansar Lake have not been studied. In order to determine how best to use and manage the lake's water, this study evaluated the quantity and quality of the lake's water**.** [7].

2.2.1 STUDY OF ZOOPLYNKTONS AND WATER PRODUCTIVITY LAKES IN JAMMU:-

(Kumar et al., 2006)

Surface runoff and subterranean springs supply freshwater to the lake. The hills rising to a height of 700–800 meters encircle the lake, creating an evergreen canopy with a variety of plant species (Kumar and Singh, 2006). The current research location, Lake Surinsar (750 02' 30' E and 320 46' 30' N), is a lovely sweet water lake that is significant because of its invaluable historical, cultural, and ecological assets. [8].

2.3 TOURISM IMPACT ON PHYSCIO-CHEMICAL PARAMETERS:-

(Kumar et al.,Sheetu dhar 2006)

The tourism business is mostly dependent on natural resources, and thus has an impact on the quality of the air, water, and land. Any water body's major tourist destination receives a large influx of visitors throughout the year. Their activities, such as boating, feeding fish flour balls, eating, and discarding waste into the water, put additional strain on the body of water, increase pollution, and degrade the quality of the water. [7].

2.4 WATER QUALITY ASSESSMENT:-

(Kumar et al., D. Salathia 2006)

There is already evidence of a direct correlation between total dissolved solids and electrical conductivity in water quality. The spike in TDS seen in the winter months could be explained by the upwelling of inorganic salts and ions that are produced following the breakdown of organic waste from bottom layers during lake overturn and by the uniform mixing of water throughout the winter months. The temperature of the water, the time of day, the season, the depth, the altitude, and the flow rate are some of the variables that affect dissolved oxygen levels. According to Slathia and Dutta, mixing of the CO2-rich hypolimnion water with the epilimnion during lake overturn may be the cause of the wintertime increases in free CO2 in Mansar Lake. [8].

(Kumar et al., 2006,Rathinasamy Maria Saleth, 2011).

They can be used as tourist attractions and also improve the scenic attractiveness. These lakes play a major part in maintaining the region's hydrological, ecological, and natural balance. They are also a mirror of their watershed since the materials that enter them are determined by the terrain, soil, geology, and vegetation of the watershed, which in turn influences the water quality. A recognized Ramsar site, Lake Mansar (32 0 48'N and 75 0 23'E) is situated in the Shivalik belt around 55 km east of Jammu City, together with another lake named Surinsar. Mansar, with a radius of 3.4 km, a depth of 38.25 m, and an area of 0.59 km 2, is semi-oval in shape and is located at an elevation of 664 meters above sea level. This mild, monomictic, non-drainage lake receives surface runoff from the watershed and freshwater from underground springs in addition to being primarily supplied by rainfall. These indicators, which are currently apparent in a few areas of India, are about to spread throughout the entire nation and could eventually become a permanent part of the water sector there if appropriate measures are not taken swiftly to regulate water supply and demand at various levels. [30].

2.5 GROUND WATER QUALITY ASSESSMENT:-

Anke Kirch, 2002;Vijay Kumar et al. 2006;Palmer et al. 2007;Petts, 2009;Chen et al. 2012;Chen et al. 2013;Ming Dou et al. 2016:Nagaraju et al .2017and Getahun and Keefer 2016:-

Previously, a great deal of research has been done on this topic. In fact, because of the research area's semi-arid topography, crystalline basement, and the spatial distortion between water-producing and water-consuming areas, there are currently water shortages. [9].

2.6 HYDRO-CHEMOSTRY AND WATER QUALITY OF REWALSAR LAKE OF LESSER HIMALAYA,HP,INDIA:-

Singh et al. (2016),Kumar et al. (2006); Khadka and Ramanathan (2012); Sheikh et al. (2014) and Singh et al. (2016):-

An earlier study by Singh et al. (2016) also found similar sorts of water in the Chandra Tal Lake. Similar to studies conducted by Kumar et al. (2006), Khadka and Ramanathan (2012), Sheikh et al. (2014), and Singh et al. (2016) from other lakes such as Wular, Mansar, Begnas, and Chandra Tal, the Rewalsar Lake has also demonstrated the dominance of alkaline earth over alkali metals during pre-to post-monsoon seasons. In addition, weak acid (HCO_3^-) predominates over strong acid (SO_4^{2-}) in Rewalsar Lake during all seasons. This is consistent with observations made by Chakrapani (2002) from other Himalayan lakes, such as Nainital, Bhimtal, Sattal, and Naukuchiatal. [10].

Khadka and Ramanathan 2013) (Chakrapani 2002, Kumar et al. 2006:-

However, because lakes have stagnant water that is unable to purify themselves, they are far more vulnerable to water pollution than other types of bodies of water (Khadka and Ramanathan 2013). The physicochemical characteristics of water are changed by extraneous fertilizer sources or any other kind of man-made obstruction, and this has an impact on the diversity of plants and animals in and around the lake (Chakrapani 2002, Kumar et al. 2006). India has a large number of lakes, both man-made and natural, spread throughout its many regions. Forward and return migration frequently take separate pathways. 71 Larger birds often fly in flocks. Flying in flocks lowers the amount of energy required. [11].

CHAPTER 3
SEWAGE TREATMENT TECHNOLOGIES
3.0 SEWAGE TREATMENT TECHNOLOGIES :-

In sewerage systems, conventional sewage treatment methods including the Upflow Anaerobic Sludge Blanket (USAB) Reactor, Waste Stabilization Pond (WSP), and Activated Sludge Process (ASP) are frequently used to treat wastewater up to secondary level in accordance with effluent standards[13].

A variety of more advanced treatment technologies have recently been implemented; nevertheless, they do not, in and of themselves, demand attention as listed below. The challenge is in the design base, which must be standardized in order to be used in government-funded projects.

Here are a few of the comparatively more well-known technologies.

- Moving Bed Bio Reactor (MBBR) / Fluidized Aerobic Bio Reactor (FAB)
- Membrane Bio Reactor (MBR)
- Sequencing Batch Reactor (SBR)

While certain other cutting-edge medical technologies have recently been implemented in other regions of the world, they have not yet seen widespread adoption in India. In order to determine the techno-economic viability of the following technologies, even though they have only been tried out at random thus far, more research and perhaps even a pilot or demonstration project in India is required. The tools are:

- BIOFOR Technology (Biological Filtration and Oxygenated Reactor)
- High Rate Activated Sludge BIOFOR-F Technology
- Submerged Aeration Fixed Film (SAFF) Technology
- Fixed Bed Bio Film Activated Sludge Process (FBAS)
- Rim flow Sludge Suction Clarifiers/Bio Tower
- Improved Circular Secondary Clarifier
- Eco-Bio Blocks

3.1. SEQUENCING BATCH REACTOR (SBR)

By combining primary setting, aeration, secondary settling, and decanting the treated sewage in a succession of sequential or simultaneous reactions in the same basin on a time-deferred cycle, this ASP technology variation is essentially a batch treatment [14]. As a result, the treated sewage will be settling and being released into another tank in a cyclically repeated process. It is preferable to utilize fine bubble, non-clog membrane diffused aeration with high efficiency. The biokinetic reaction rate in this non-steady state batch process needs to be assessed due to its increased rate, which differs from the well-known reaction kinetics of continuous flow steady state ASP for our sewage characteristics.

3.1.1. ADVANTAGES OF SBR TECHNOLOGY

1. Can eliminate Phosphorous and Nitrogen simultaneously with BOD
2. The absence of corrosive gasses and an odor
3. Better aesthetics
4. When compared to traditional activated sludge processes, the footprint can be reduced by making effective use of shared walls, simple square, rectangular, or circular buildings, and eliminating the need for separate secondary clarifiers and large return sludge pumping stations.
5. The ability to control and handle varying loading circumstances, including shock loads, normal, diluted monsoon, and diurnal loads.
6. Because automatic control is easy to use and maintain, it requires less staff.
7. Reusable high-quality effluent without the need for additional fertilizer removal or fine filtration.
8. Capable of growing as a modular system.
9. For bio-methanation and energy recovery, it can also be utilized in conjunction with traditional F/M ratio and primary clarifiers.
10. The system is able to produce a stabilized sludge.

3.1.2. DISADVANTAGES OF SBR TECHNOLOGY

1. There is no provision for managing sludge.
2. Lack of a primary treatment to reduce changes in pollution load; increased energy input if bio-methanation is not employed; requires at least semi-skilled labor.
3. Decanters and patented process techniques that resist local cannibalization

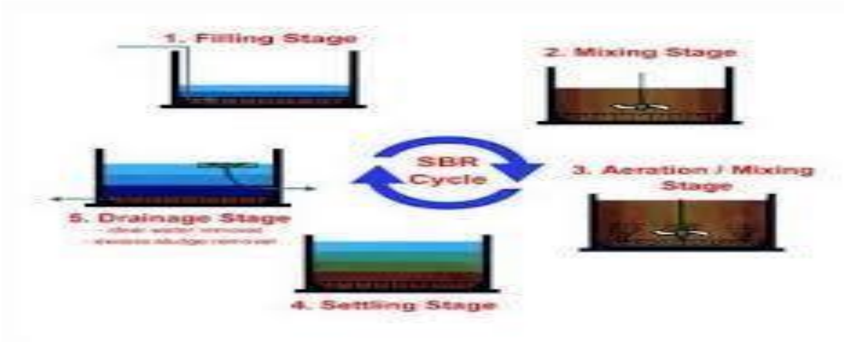

Fig 3.1. Cycle of sequencing batch reactor

3.2. Moving Bed Bio Reactor Fluidized Aerobic Bioreactor (FAB)

This technology is essentially the same as activated sludge, with the exception that the media suspended in the reactor provides more surfaces for the microbes to grow on. As a result, it appears to be preferable to conventional aeration without the media in that regard, as it maximizes the growth of microbes in a given volume of aeration tank [15]. Naturally, diffused aeration is required. Similar to MBBR, FAB technology maintains the media fixed and fluidized within the aeration tank rather than suspending it.

3.2.1. ADVANTAGES OF FAB TECHNOLOGY

1. Height restrictions do not exist as long as compressors are used appropriately.
2. It is possible to save money and time on building by using circular constructions.
3. When it comes to interior air quality, the structures are easily covered.
4. Minimizes footprints in comparison to traditional activated sludge
5. Simple to use and keep up

3.2.2. DISADVANTAGES OF FAB TECHNOLOGY.

- It is challenging to establish a single, proven set of standard design requirements since different manufacturers offer varying areas per unit volumes of media, and each vendor promotes different standards for the volume of media to the volume of the aeration tank. The media's plastic varies in quality.

- It is important to check if the media is moving throughout the tank or just clumping at the top layers. If the latter, how to mix the media throughout the tank volume without shearing the biomass on top of it? There may be problems with this and the media may need to be gently moved throughout the tank volume.
- Greater energy consumption in the absence of biomethanation.
- Moreover, the media is a product that is patented.

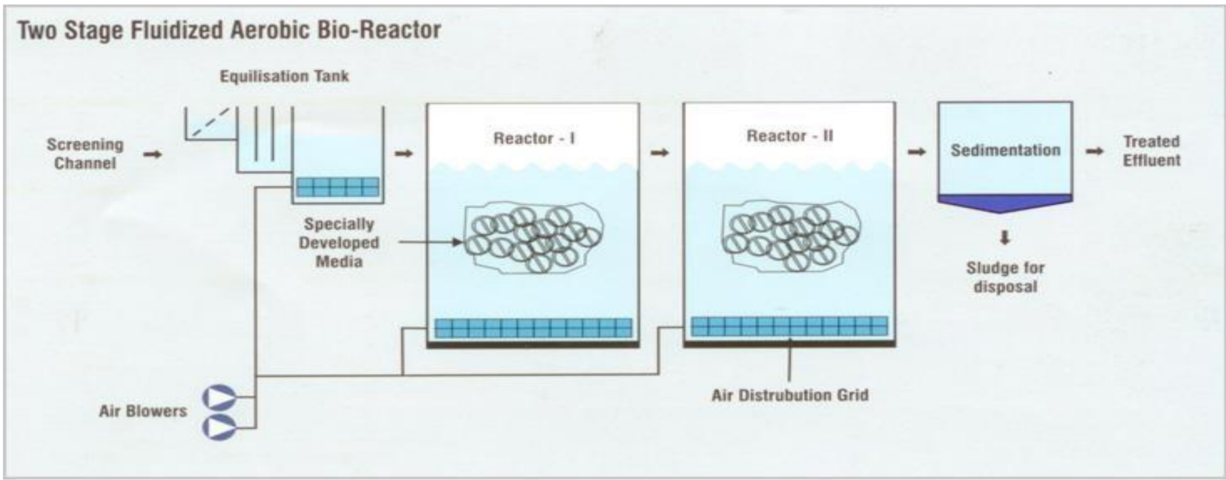

Fig.3.2 Schematic diagram of fluidized aerobic bio reactor

3.3 MEMBRANE BIO REACTOR (MBR)

In addition to its claimed ability to hold and sustain mixed liquor suspended solids (MLSS) of three to four times what is possible in the conventional aeration tanks, this technology combines the aeration and secondary clarifier in one and the same tank by sucking out the aerated mixed liquor through membranes instead of settling in a separate downstream tank. To that extent, it does yield a treated sewage with practically no BOB and suspended solids and being clear and virtually transparent. Of course, diffused aeration is necessary.[16]. The membrane is a matter of proprietorship, and each vendor offers a different membrane module. Additionally, each vendor promotes different membrane shapes, such as flat sheet, cross flow, dead end flow, etc., making it challenging to develop universally accepted standard design criteria.

3.2.3. ADVANTAGES OF MBR TECHNOLOGY

1. Reusable high-quality effluent without the need for additional fertilizer removal or fine filtration.
2. In comparison to a traditional stp, the compact system minimizes the plant footprint by 25–40%.
3. It is claimed that these membranes have a long lifespan, dependability, and a low frequency of replacement.
4. The system that is modular can be expanded.
5. Enhanced stability against organic shocks and upsets as a result of elevated mlss content.
6. Minimal suction operation makes this process minimal power consumption and the perfect filtration solution for modest to large-scale membrane facilities.

7. An automated system facilitates easier operation of the process.

3.3.2. DISADVANTAGES OF MBR TECHNOLOGY

1. Every manufacturer promotes their own standards for the sorts of membranes they offer, making it challenging to establish a single, verified design criterion.
2. Cannibalization of the system amongst different manufacturers is impossible.
3. In the absence of biomethanation, a high dependence on energy input.
4. Technologically advanced process and decanter innovations resisting local appropriation.
5. A zero-etailed assessment of the current plants, mandated by NEERI, CPCB, or IITs

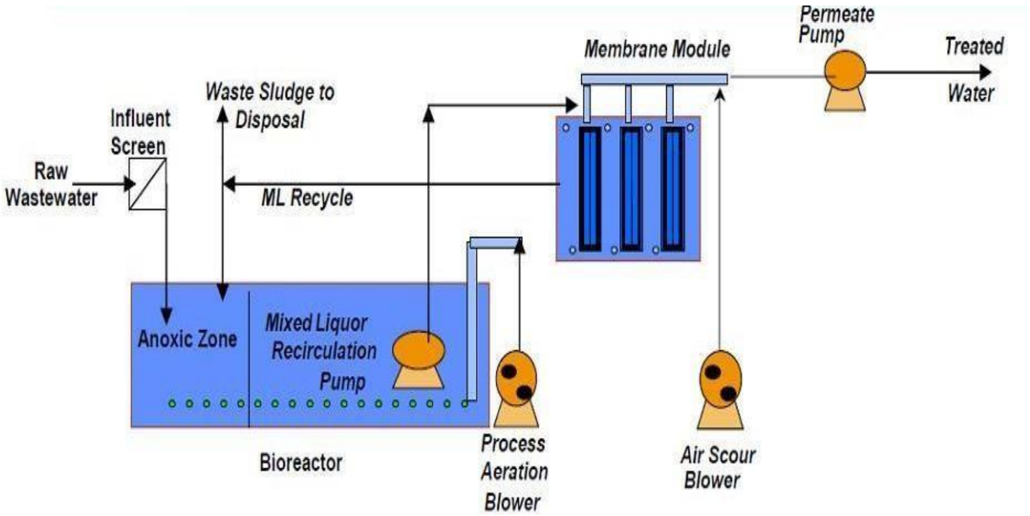

Fig 3.3 schematic diagram of submerged membrane bio reactor process

3.4 FLUIDISED AEROBIC BIO-REACTOR (FAB) A MOVING BED BIO-REACTOR TECHNOLOGY: -

An improved substitute for traditional wastewater treatment plants is the FAB waste water treatment system. Conventional treatment facilities need a lot of monitoring, are large-scale, and consume a lot of power [18]. Since FAB uses decentralized wastewater treatment technology, it is a superior substitute.
Conventional systems are no longer viable due to a lack of open space geographic plumbing networks, high power costs, and land requirements. FAB is an excellent, cost-effective treatment choice.

3.4.1. BENEFITS OF FAB

1. **SELF-REGULATING SYSTEM:** Able to withstand shock loads, the system doesn't need any parameters to be tracked.
2. **MINIMALISTIC SPACE NEEDS:** 1/10th of the normal amount of space. In order to avoid costly centralized treatment, the idea of decentralized sewage treatment plants is encouraged. The dispersed plants are easier to operate because they take up significantly less space individually.
3. **LOW TEMPERATURE SUSTAINING CAPABILITY:** The system must be able to function in low temperatures, which are experienced for at least 5-8 months of the year. This is one of the most crucial factors to consider when choosing a certain procedure. The standard activated sludge processes. Large aeration tanks are particularly vulnerable to surface layer freezing, which completely stops the

biological treatment. The bio reactor area of the systems that use the newest, most reliable technology is substantially less. For aeration, bubbles of hot air are created. [17].

4. **LOWER OPERATION POWER REQUIREMENTS:** Because the system uses considerably smaller aeration tanks, less power is needed overall to aerate the raw sewage. Because the bioreactor is deeper, oxygen is transferred more effectively, which lowers the total power used for treatment.
5. **SLUDGE HANDLING:** The bioreactors completely break down the sludge they produce. Compared to the traditional ASP system, the bioreactors generate less extra sludge due to their extremely low F/M ratio. In order to stabilize the organic matter, this sludge is often aerobically digested. The JAMMU area's severe operational climate would make anaerobic digestion extremely sluggish, inefficient, and occasionally unfinished.
6. Because the current system does not include sludge digestion, it is better suited for installation in these types of climates. The surplus sludge is sorted in the gravity thickeners and subsequently thickened. After adding the polymer, it is centrifuged immediately thereafter. Next, the dewatered sludge can be applied straight to soil as a soil conditioner.[17].

- ➢ **HIGH BIO FILM SURFACE AREA:** compact plants with high loading rates and small foot prints.
- ➢ **NON-CLOGGING DESIGN, BETTER OXYGEN TRANSFER EFFICIENCY**
- ➢ **ATTACHED GROWTH PROCESS:** No sludge recycling, low sludge production, no monitoring of MLSS.
- ➢ **SIMPLICITY IN OPERATION AND MAINTENANCE:** The system that was used has a lot fewer moving parts. Furthermore, the bioreactor's interior is devoid of any moving parts. This has the benefit of allowing the bioreactor system to operate continuously in extremely variable settings. Since all of the centrifuges, pumps, and blowers are made exclusively in India, spare parts are readily available. Any competent mechanic with a regular toolkit may perform all mechanical system maintenance.

3.4.2. AREAS OF APPLICATION

1. Municipal corporation
2. Housing colonies
3. Hotels
4. Hospitals
5. IT parks
6. Industries
7. Low/High strength industrial effluents from

⇒ Brewery
⇒ Vegetable oil refining
⇒ Poultry
⇒ Fruit processing
⇒ Rice mills
⇒ Dairy
⇒ Textiles
⇒ Food industry

3.4.3. HOW IT WORKS

Three separate sections make up the treatment plan that is suggested to handle raw sewage from different locations:

1. Pre-treatment includes grit removal and screening.
2. The process has two stages: biological treatment using fluidized aerobic bioreactors, followed by clarifying;
3. And tertiary treatment using chemicals and precipitation to eliminate phosphates and chlorine addition to eliminate the E-coil.

A thorough explanation of each therapy process is provided below:

3.4.4. PRE-TREATMENT:

In order to remove floating matter, raw sewage is pumped from the receiving sump into the bar screen chamber float. Such floating or coarse material must be removed in order to prevent clogging of pumps, pipelines, and other equipment, which would impair the treatment plant's ability to operate normally[19]. Steel bars arranged at equal intervals make up the screens. The raw sewage is forced through the screens, which catch any large particles in the bars that are trapped by the floating waste. The bars are kept at an angle that makes manual ranking simple. This now forces the screened sewage to go through the grit chamber.

Sand, mud, and other materials gathered in the sewer system are represented by the grit seen in raw sewage. The grit chamber needs to be cleared of this. She was given a grit chamber that is shaped like a long channel with a hopper-like bottom. Grit collects on the floor when the sewage is forced down this route. Shovels are then used to hand rake this grit. In order to lessen organic contaminants, the screened and degritted sewage is now sent through the biological treatment stage.

The capacity of bacteria to convert organic materials into safe byproducts

3.4.5 BIOLOGICAL TREATMENT

The two primary contaminants found in raw sewage are Chemical Oxygen Demand (COD) and Biochemical Oxygen Demand (BOD). Additionally, the nitrogen and phosphorus in the ammoniacal solution serve as pollutants. Raw sewage is treated by using the bacteria's capacity to break down organic waste into safe byproducts like carbon dioxide and water molecules[20].

Within the bioreactor, a regulated environment is used to conduct the bioreactions. The bioreactor is made up of a tank with an aeration grid installed. For the bacterial action to create the organic matter, dissolved oxygen is necessary. This is provided by air flowing by in the form of tiny bubbles. The air in the tank is forced out through the bottom, using the whole capacity of the tank. Liquid oxygen dissolves and becomes available for utilization by the bacteria. Media, a crucial component of the reactor system, contains the bacterial population. Tiny pieces of plastic make up the media. There are millions of these parts in the reactor. The bacterial population has an extremely vast surface area to grow on. By using the organic material in the raw sewage and the available dissolved oxygen, the bacteria spread over the plastic medium. The media is kept in motion by continuous aeration, which results in continual mixing[19]. After a given amount of time, the bacterial layer development on the media surface sloughs off after increasing to a particular point. We refer to this occurrence as sloughing. This produces more surface area for the development of germs. Sloughing occurs only when the bacterial layer has finished growing and dying off; as a result, the material that has been sloughed off has been fully digested. In the process of bacterial production, ammoniacal nitrogen is entirely transformed into nitrate nitrogen. The organic synthesis also

uses about 50–60% of the phosphates. Two steps of the bacterial reaction are conducted in order to maximize the removal effectiveness of BOD. As a result, two of these reactors are offered in series. There are mechanisms in place within the reactors to keep the plastic medium in situ.
Air supply is done through perforated stainless steel pipes. Use of stainless steel pipes ensures that no maintenance is required.

3.4.6 TERITIARY TREATMENT

Before the treated sewage can be disposed of, the sloughed biomass needs to be removed. Thus, a backup clariflocculator is offered [21]. A piece of equipment that combines flocculation and clarifying is the secondary clariflocculator. Giving out a clariflocculator also serves the additional function of flocculating the phosphates upon the addition of alum or PAX. An insoluble salt known as aluminum phosphate is created when aluminum and phosphates combine. Good floc formation and, thus, good settling are guaranteed by the flocculator supplied.
Chlorine is subsequently added to the treated sewage to eradicate microorganisms and make it suitable for dumping in lakes and rivers. Because chlorine is an extremely potent oxidizing agent, the required levels of disinfection can be reached with just a little amount of 2-3 mg/l. Toilets consume a small amount of leftover chlorine.
To improve consistency, the sludge that forms during biodegradation and as a result of coagulants being added is fed to a thickening. After that, a centrifuge of the decanter type is used. Centrifuge force is the basis for how the decanter centrifuge operates. A high-speed rotor receives the sludge, which has a consistency of roughly 3-4%. The solids with a high specific gravity are expelled to the periphery and eliminated as concentrated sludge. The thickening overflow and cent rate are recycled back into the system. You can utilize the bottom sludge from the centrifuge to condition soil.

CHAPTER- 4
C-TEST SYSTEM OR SEQUENCING BATCH REACTOR SYSTEM (SBR)

4.0 C-TEST SYSTEM OR SEQUENCING BATCH REACTOR SYSTEM (SBR):- The cyclic activated sludge process is becoming more and more important in the treatment of wastewater, primarily because of its easy operation and flexibility in design to accommodate fluctuations in daily flow and load. Using cyclic activated sludge technology, the process of adjusting the activated sludge reaction environment to achieve maximum nitrogen and biological phosphorus removal has been refined. This method allows for the sequential and continuous operation of the fill, aeration, settle, and decant sequences in a compartment mechanism, resulting in phosphorus levels below 5 gm/lit through a contemporaneous nitration mechanism. Additionally, phosphorus levels below 5 gm/lit can be achieved without the need for chemical addition. [22].

4.1 HISTORICAL BACKGROUND

The term "C-TECH System" particularly refers to the employment of variable volume treatment in a fed-batch reactor design in conjunction with a biological SELECTOR and BIORATE control. Originating in Australia, the Cyclic Activated Sludge Technology is a spin-off of sequencing batch reactor technology (SBR). Later, it was modified to fit the local climatic and discharge requirements of Central Europe and Asia after being created for North American conditions.[21].

4.2. EXPLANATION OF CYCLIC OPERATION

A basic cycle comprises of:

- Fill-Aeration
- Settlement
- Decanting

These steps taken one after the other form a cycle that is then repeated. The liquid volume in the tank rises during a cycle from a predetermined minimum operating bottom water level. At a specific point in the cycle, aeration stops to allow the biomass to settle and flocculate under quiescent circumstances. Using a moving weir, the treated supernatant is extracted (decanted) after a certain amount of time to settle. The cycle is then repeated after the liquid level in the vessel has been brought back to the bottom water level. During the decanting process, solids are wasted from the tanks.

4.3 FILL-AERATION (F/A)

The period of air-on time that influent is introduced into the basin is referred to as aeration. During the nominal aeration sequence, multiple basin facilities can operate with various air-on sequences [23]. When operating at a load below design, it is usually necessary to stop the primary response to the in-basin dissolved oxygen content, or BIORTE. Mixed liquid from the aeration zone is recycled into the selector during the fill-aeration procedure. This means that, in comparison to daily influent, the overall recycle rate (20–30%) is substantially lower than in typical systems.

4.4 SETTLEMENT(S)

This sequence refers to the first phase of the air-off sequence, during which the conditions necessary for solids-liquid separation are established. As the solids compress, the sludge mass creates an unmistakable sludge level interface that gradually descends. An excess layer of clear supernatant is left behind as the activated sludge floc particles stick together and the material settles inside a blanket. In most residential waste water systems, the biomass concentration of the settled layer is approximately 10g/l on average. [24].

4.5 DECANTING

There isn't any inflow into the basin when decanting. Driven by a motor, the moving weir DECANTER moves gradually from its out-of-liquid-rest position to a predetermined water level at the bottom. Reversing the drive allows the weir to return to its rest position[25].

4.6 SPECIAL FEATURES

4.6.1 CO-CURRENT NITRIFICATION AND DENITRIFICATION

With a cyclic method, waste water can be treated with nitrification/denitrification (N/DN) without the need for anoxic mixing or liquid recirculation. Traditionally, oxic, anoxic, and anaerobic conditioning create favorable chemical, biological, and biochemical conditions for nutrient removal reactions in the activated sludge process[26]. Numerous nutrient removal methods rely on continuous flow principles, employing distinct basins for every reaction condition and substantial recycle flows amongst the basins. The following factors must be able to be adjusted in order to favor the desired reaction for N/DN: pH, dissolved oxygen, ORP, nitrate substrate, and different recycling rates. In order to provide the necessary process flexibility, basin construction, mechanical equipment, and connecting mixers and pipes must all be taken into account. Co-current N/DN, on the other hand, streamlines the recycle and recirculation flows that traditional systems need. The extent of process flexibility that is obtained from the ability to easily modify the time cycles of operation in situations of prolonged load deviation is a major advantage of discontinuous processes. The rates of nitrification are roughly 35% higher than in the traditional system. Co-current N/DN refers to reaction circumstances that allow nitrification and de-nitrification to occur simultaneously in the same reaction basin without the need for any particular anoxic mixing sequences. This allows for the biological selector to be used to reduce nitrate. The entire nitrification and de-nitrification process occurs in the same basin, with the de-nitrification process occurring inside the activated sludge flocs and the nitrification process occurring outside of them. This de-nitrification process does not require the presence of dissolved oxygen in the liquid phase; instead, it necessitates the diffusion of nitrate into the anoxic portions of the floc, most likely with the aid of stored or adsorbed organic carbon inside the cell. Intracellular carbon storage is facilitated by the combination of a biological selector at high organic loading.

4.6.2 BIOLOGICAL SELECTOR ZONE

The biological selector that is included into the C-TECH-Systems sets it apart from all other technologies. Because of this process characteristic, a FILL-AERATE sequence can be used in place of the ANOXIC-MIXING sequence, which is no longer necessary. The SELECTOR makes the process easier to run and ensures that mostly floc-forming microorganisms are biologically selected at all loadings, especially when the load is lower than the design load. The biological separator functions in an anoxic to anaerobic reaction environment, quickly removing the waste water's soluble organic content by enzymatic transfer mechanisms. These soluble organic materials, mostly acetates, are converted into intracellular storage products very fast [25]. Together, the biological SELECTOR helps in the poly P microorganism selection process. This zone is reached by recirculating activated sludge and using 4-hour cycles, which exposes the biomass to the right reaction conditions. This encourages the selection of microorganisms that accumulate phosphate. It is possible to successfully include every known low F/M bulking microbe in the biological selector. The aforementioned unique mode of operation has demonstrated efficacy in containing Nacardia and Microthrix Pavicella, which frequently result in bothersome surface foaming. This area has diffusers in case periodic flash mixing is needed.

4.6.3 BIORATE CONTROL

Dissolved oxygen (DO) measurement was employed by BIORATE control to create a process repirometer that operates at full scale. In this case, the biomass's metabolic activity is assessed within the process basin and then utilized as a control parameter to automatically adjust the aeration sequence's duration and rate[27]. This approach offers a real in-basin technique for energy efficiency. The BIORATE operation results in a minimum 15% energy savings and a maximum 80% energy savings. At the end of the cycle, the DO concentration profile is automatically scaled to function at slightly higher DO concentrations. This characteristic inhibits the proliferation of filaments of the low dissolved oxygen type. Cycles are programmed to ensure that there is an adequate supply of oxygen to meet process requirements. The oxygen utilization rate (BIORATE) of the biomass provides an easy way to measure the process oxygen requirements in a facility. If the process is run longer than what is required to meet the oxygen requirements, there will be less denitrification and less biological phosphorus removal. Over-aeration is a

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common cause of turbid effluents.

4.6.4 BIOLOGICAL PHOSPHORUS REMOVAL

The biomass oxidation reduction potential decreases throughout settlement and decant, going from a positive value of around +50 to +100 mV to a negative value of approximately –150 to –200 mV. This particular reaction condition is necessary for the biological phosphorus absorption system to function. All phosphorus released into the liquid phase under anaerobic circumstances is entirely confined within the biosolids layer. There is no diffusional release of phosphorus into the liquid phase above when the system is run for biological phosphorus removal[27]. The PLC also controls the automatic basin air distribution system.

4.6.5 OPERATIONAL SIMPLICITY

The plants near total automation contributes significantly to lower operating expenses. A Programmable Logic Control (PLC) controls the flow of each batch process and the timing of each sequence interval [28]. Included is control for each decanter, sludge pump, and other equipment. The PLC also controls the automatic basin air distribution system. This implies that performance and optimal operation go hand in hand; steady state performance is ensured by the ease with which high and low load conditions may be managed.

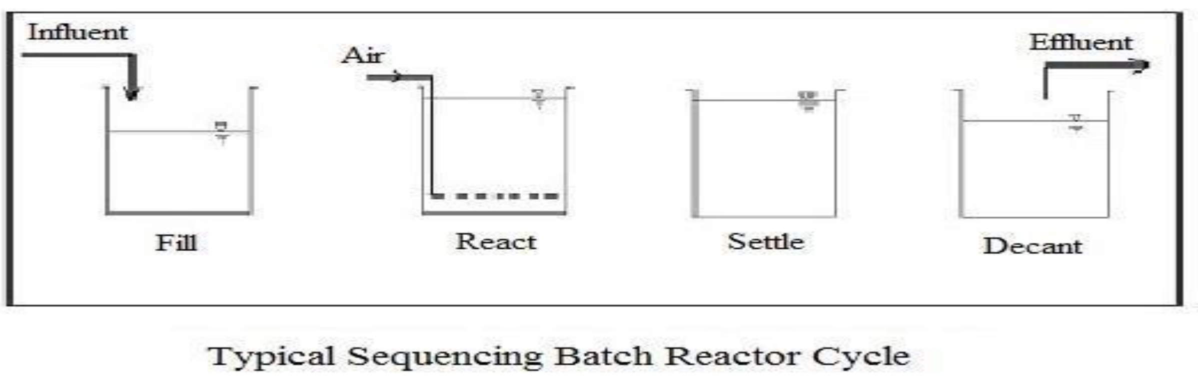


Figure 4.6.5shows typical aquencing batch reactor

4.7 SEWAGE TREATMENT:-

The goal of sewage treatment is to get rid of pathogens as well as suspended sediments, floating material, and biodegradable organics that are present in waste water. Unit operations and unit processes, which are common to all systems as preliminary and primary treatment, provide a plethora of possibilities that are currently available. Unit procedures are limited to particular circumstances where disinfection, adoption, or precipitation are thought to be desirable[29]. the availability in sewage under a wide range of environmental circumstances. The biological treatment that is widely used nowadays consists of a series of procedures meant to eliminate contaminants through films, flocks, or biomass development. Systems of attached or suspended growth may be used to bring this about. It is primarily caused by the synthesis of new cells and the oxidation/reduction of organic materials.

The layout of conventional wastewater treatment plant is as follows:

Domestic Waste water | Preliminary treatment | Primary Treatment | Secondary or biological | Tertiary or advanced | Disposal in treatment Treatment water bodies

Table 4.1. Indian Standards of discharge of sewage in surface waters are given:

S.NO	Characteristic of the effluent	Tolerance limit for discharge of sewage in surface water sources.
1	BOD5	20mg/L
2	TSS	30mg/l
3	COD	<100mg/l
4	Ph.	7-8
5	PO4`	More than 90% removal
6	NH_3-N	More than 90% removal

Depending on unit operations and unit processes employed, sewage treatments are classified as follows:

- Preliminary Treatment
- Primary Treatment
- Secondary or Biological Treatment
- Tertiary Treatment

4.8 PRELIMINARY TREATMENT OF SEWAGE

Sewage is first treated by using techniques like grit removal, screening, skimming, and flotation. The following are removed from sewage via preliminary treatment:

1. Floating materials, huge floating materials, wood pieces, tree branches, papers, rags, etc.
2. Heavy, easily settled inorganic substances, such sand, grit, and broken pieces of masonry;
3. Oils, fats, and grease

Various units of appurtenances employed in this are:

1. Screens
2. Grit chambers
3. Skimming tanks
4. Flow equalization units

4.8.1 SCREENING

The first procedure done at a sewage treatment facility is screening. The process involves putting sewage through a screen to catch and eliminate floating debris that could clog and harm pumps and other machinery. A screen is an apparatus that typically has holes of the same size. The screening element can be made out of perforated plates, wire mesh, grating, parallel bars or flats, rods or wires, or any combination of these. The apertures can be any shape, however they are typically round or rectangular. A rack, bar rack, or bar screen is a screen made up of parallel bars, flats, or rods. Screens can be categorized as coarse, medium, or fine depending on the size of the openings [29].

Flow equalization is simply the damping of flow rate variations so that a constant.

4.8.2 GRIT REMOVAL-GRIT CHAMBERS.

Grit, which includes sand, gravel, silt, ash, cinders, clinkers, egg shells, bone chips, and other inert inorganic debris, makes up a significant portion of sewage. Grit typically has a specific gravity between 2.4 and 2.64. Grit removal is required to prevent abnormal wear and abrasion of the pump elements and moving mechanical equipment that comes with cleaning sludge digesters frequently. There are grit chambers available to filter grit out of sewage[22]. A grit chamber is a long, enlarged channel or basin with a raised cross section that lowers the flow velocity of sewage to the point where the heavier grit settles at the bottom and the lighter organic matter is suspended and is therefore carried with the grit chamber's effluent for additional treatment. Therefore, the most crucial factor in the construction of grit chambers is that the sewage flow velocity should cause all of the grit in the sewage to settle.

4.8.3 SKIMMING TANKS

A device known as an aerating device blows air into the bottom of a rectangular or circular tank known as a skimming tank, while sewage flows through it. The oily substance rises to the surface and is forced into a side compartment where it is removed as a result of the air bubbles coagulating and congealing it. [30].

4.8.4 FLOW EQUALIZATION

Nearly all sewage treatment plants receive sewage that varies greatly in strength and flow rate. There could be a decline in performance from the best possible outcome due to these variances. Flow equalization may be utilized to improve the performance of the downstream operations and get around the operational issues brought on by these changes. To create a constant or almost constant flow rate, the process of dampening down flow rate variability is known as flow equalization. Equalization of flow in sewage treatment can be accomplished through either in-line or off-line configuration.

4.9 PRIMARY TREATMENT

The elimination of big suspended organic particles is the first step in therapy. Usually, plain sedimentation tanks or settling tanks—also referred to as primary sedimentation tanks or primary clarifiers—are used for sedimentation to achieve this. The anaerobic decomposition that stabilizes the organic solids separated out in the sedimentation or settling tanks during initial treatment typically results in a high BOD (about 60% of original) and a significant volume of suspended organic material. [30].

4.10 SECONDARY OR BIOLOGICAL TREATMENT.

The biological treatment of sewage aims to stabilize the organic matter with the aid of microorganisms (bacteria) and coagulate and eliminate the colloimansar solids that cannot be settled [30]. Reducing the organic content and, when applicable, the nutrients—specifically, phosphorus and nitrogen—that can promote the growth of aquatic plants is the main goal when it comes to domestic sewage. Removing or lowering the concentration of organic and inorganic chemicals in industrial effluent is the goal.

Generally speaking, biological treatment of sewage entails:

1. The removal of the cell tissue, which often happens by gravity settling in secondary settling tanks;
2. The conversion of the dissolved and colloimansar organic matter contained in sewage to biological cell tissue and end products.

Therefore, from a practical standpoint, the main issues with biological sewage treatment are the establishment of the ideal physical and environmental conditions to facilitate the quick and efficient conversion of organic materials to cell tissue and the removal of that tissue.

4.10.1. CLASSIFICATION OF BIOLOGICAL TREATMENT PROCESES:

Both aerobic (with oxygen present) and anaerobic (without oxygen) biological conversions of organic matter are possible. Accordingly, biological treatment techniques can be categorized as follows based on whether or not the microorganisms converting organic matter require oxygen:

- **AEROBIC PROCESS:** Aerobic processes biological treatment processes that occur in the presence of oxygen.
- **AN AEROBIC PROCESS:** Anaerobic processes are biological treatment processes that occur in the absence of oxygen.

  Because aerobic bacteria are approximately three times more active than anaerobic bacteria at room temperature, aerobic conversion techniques are typically chosen in biological treatment procedures because they result in a much faster rate of conversion than anaerobic conversion.

  Although the microorganisms that convert organic waste can be kept in suspension or adhered to a stationary or moving media, the biological treatment processes mentioned above can be further classified as:-
- The procedure known as "suspended growth" is a biological treatment method in which the organic materials or other ingredients found in sewage are converted to gasses by bacteria, while the cell tissue gets suspended in the liquid.
- **ATTACHED GROWTH PROCESS:** This type of biological treatment involves the attachment of cell tissue to an inert medium, like rocks, slag, or specially formulated ceramic or plastic materials, while microorganisms are in charge of converting organic matter or other constituents in sewage to gases. Another name for the attached growth method is the fixed film procedure.
- **COMBINED PROCESS:** The most widely used aerobic suspended growth biological treatment method is activated sludge. The combined process is a biological treatment method in which the microorganisms that convert organic matter or other constituents present in sewage to gasses and cell tissue are maintained in suspension within the liquid as well as attached to some inert medium. Aerated lagoons, aerobic algal ponds, and oxidation ditch are some other often utilized aerobic suspended growth biological treatment methods[30].
- The aerobic attached growth biological treatment method that is most frequently utilized is the trickling filter method and its variants. The medium that the microorganisms are adhered to is fixed in a trickling filter.

4.11 TERTIARY TREATMENT OR ADVANCED TREATMENT:

All procedures and methods used to eliminate pollutants not eliminated by conventional treatment are included in tertiary, or advanced, treatment. These pollutants could be suspended or dissolved materials, pathogens, viruses, leftover organic debris, inorganic solids, and inorganic nitrogen and phosphorus compounds, among other things. Sewage treatment is typically limited to secondary treatment alone[28]. When reusing wastewater for industrial or other purposes is being considered, or when conditions demand the use of higher quality wastewaters—for instance, to prevent eutrophication in receiving waters—tertiary treatment is implemented. The tertiary therapy often consists of the subsequent techniques:

- Sand filtering eliminates a significant portion of the remaining suspended particles. Remaining contaminants are eliminated by filtering over activated carbon.
- Constructed wet lands, which offer a high degree of aerobic biological improvement and can frequently be employed in place of secondary treatment for small populations, comprise engineered reed beds and a variety of related techniques.

- **NUTRIENT REMOVAL**: High concentrations of nutrients, including phosphorus and nitrogen, may be present in wastewater. Over-release of nutrients into the environment can cause eutrophication, a nutrient buildup that can promote the overgrowth of weeds, algae, and cyan bacteria (blue-green algae). This could result in an algal boom, or a sharp increase in the number of algae**.** The majority of the algae eventually die since they are not sustainable. More organic matter is produced for the bacteria to break down as a result of the animals dying from the oxygen in the water being depleted by the bacteria's breakdown of the algae. Certain algae species not only deoxygenate environments but also release toxins that contaminate supplies of drinking water[28]. Nitrogen and phosphorus removal require different treatment procedures.
- **DISINFECTION:** When treating waste water, the goal of disinfection is to significantly lower the amount of microorganisms in the water that will be released back into the environment. The efficacy of disinfection is contingent upon various environmental factors, disinfectant type, disinfectant dosage, and water quality. Generally speaking, cloudy water will be harder to disinfect effectively due to solid matter's ability to shield organisms, particularly from ultraviolet light or short contact times[25]. In general, high flows, low dosages, and brief contact times all work against efficient disinfection. Ozone, chlorine, and UV light are common disinfection techniques. Because of its persistence, chloramine—which is used to treat drinking water—is not employed in the treatment of waste water.

Disinfection techniques include:

1. Chlorination
2. Ultraviolet radiation
3. Ozone (O3)

CHAPTER 5

EXPERIMENTAL STUDY FOR COMPARISON OF FAB & SBR

5.1 pH

Method: POTENTIONMETRIC

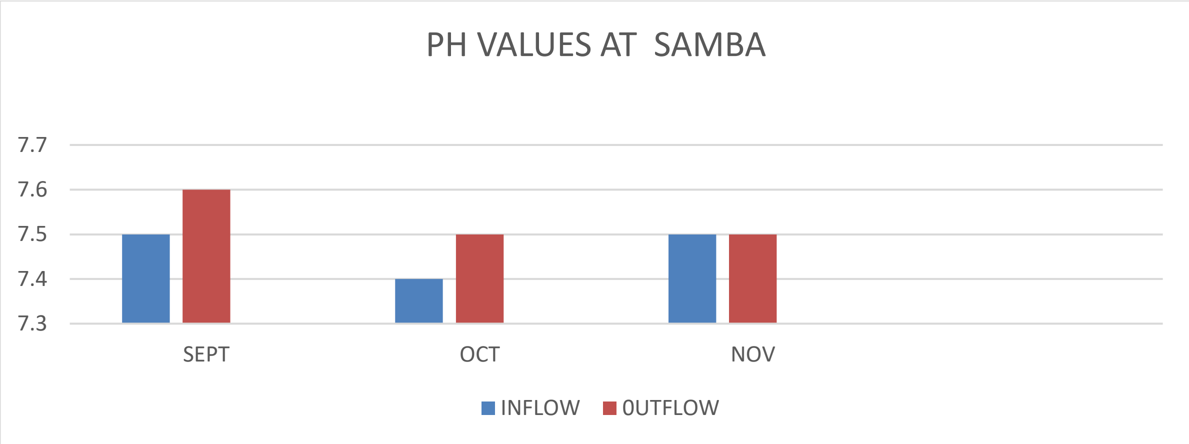
Procedure:

As directed by the manufacturer, remove the electrodes from the storage solution, rinse, wipe dry with tissue, place in the initial buffer solution, and standardize the pH meter. After removing the electrodes from the first buffer, thoroughly rinse with distilled water, pat dry, and then submerge in the second buffer, ideally with a pH that is no more than two units lower than the sample's pH. [22] Check the pH, which ought to be within 0.1 units of the buffer's second pH. Once equilibrium has been established between the electrode and the sample, calculate the pH of the sample using the same method as for the second buffer above. This can be accomplished with buffered samples by submerging the electrodes for one minute in a fraction of the sample. After blotting dry, dip a new section of the sample in it, and measure the pH. With dilute poorly buffered solution, equibrate electrodes by immersing in 3 or 4 successive portion the sample. Take a fresh sample to measure ph. Stir the same gently while measuring pH to ensure homogeneity [23].

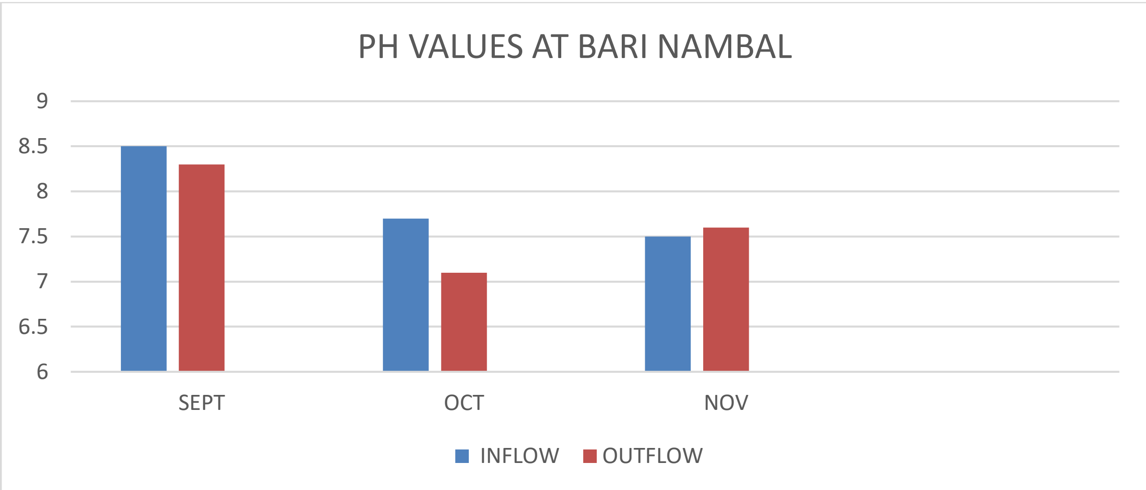
Table 5.1: **- Observation for pH test between Samba and Jammu: -**

SAMBA S.T.P. (FAB)			**JAMMUS.T.P.(SBR)**		
DATE OF SAMPLING	INFLOW	OUTFLOW	DATE OF SAMPLING	INFLOW	OUTFLOW

16/09/2019	7.5	7.6	20/09/2019	8.5	8.3
20/10/2019	7.4	7.5	25/10/2019	7.7	7.1
25/11/2019	7.5	7.6	30/11/2019	7.5	7.6



Graph 5.1 -Bar Diagram depicting changes in ph. Value in samba



Graph 5.1 -Bar Diagram depicting changes in ph. Value bari nambal

5.2 BIOCHEMICAL OXYGEN DEMAND (5 days, 20^0c)

Method: bottle incubation for 5-day at 20^0c

An invaluable test for analyzing sewage, industrial effluents, and extremely polluted water is biological oxygen demand, or BOD. The term "BOD" describes the amount of oxygen used by bacteria and other microorganisms during the aerobic metabolic breakdown and transformation of organic matter[24].

PRINCIPLE:

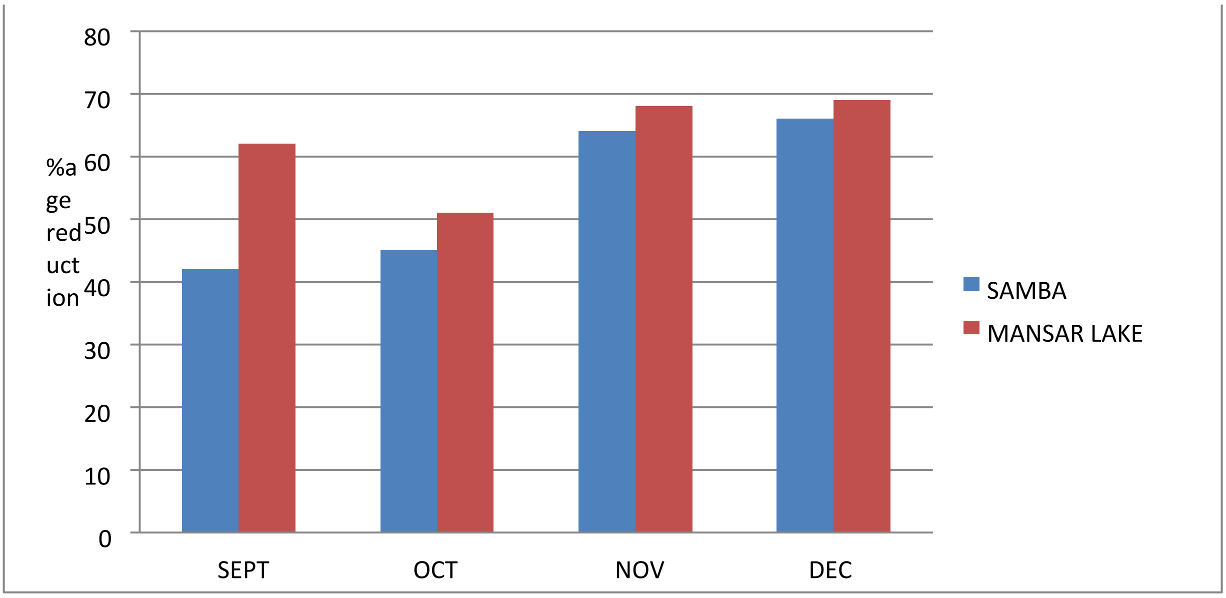
Measuring the sample's dissolved oxygen concentration both before and after five days of incubation at 200C forms the fundamental basis for determining BOD. To supply enough oxygen for oxidation, samples that are either oxygen-free or contain very little oxygen are diluted multiple times using a particular kind of dilution water that is saturated with oxygen.

DETERMINATION OF BOD: To determine the initial dissolved oxygen content, use dilution water and one set of sample dilutions. For five days, keep the other set of sample dilution and water at 200C in the dark in the BOD incubator. measuring the DO content of the sample and diluted water on the first day and

five days later.
[(DOi - Dof) *100.0%mixture] = BOD (mg/l)

Table 5.2 :- Observations for BOD test between Samba & Mansar lake

SAMBA S.T.P. (FAB)				**MANSAR LAKE** S.T.P. (SBR)			
Date of sampling	Inflow (mg/l)	Outflow (mg/l)	%age reduction	Date of sampling	Inflow (mg/l)	Outflow (mg/l)	%age reduction
15/09/19	176	101	42	20/09/19	290	109	62
20/10/19	189	104	45	25/10/19	212	104	51
25/11/19	282	101	64	30/11/19	323	101	68
15/12/19	312	105	66	15/12/19	310	102	67



Graph 5.2- Monthly variation in %age reduction of BOD in 2019

5.3 CHEMICAL OXYGEN DEMAND:

As the name suggests, COD is a sample's organic need for the oxidation of both organic and inorganic materials. Since the amount of oxidizable inorganic matter is typically much smaller than that of organic matter, COD is typically regarded as potassium dichromate's oxygen equivalent of organic matter. The amount of oxygen (mg/l) consumed under particular conditions in the oxidation of organic and oxidisable materials in organic matter, adjusted for the influence of chlorides, is the definition of chemical oxygen demand given by ASTM.

The COD test is advised as an addition to the BOD test. The main benefit of the COD test is that it can be completed quickly, whereas the BOD test takes five days to complete[25].

Principle:

1. Fill a 500 ml refluxing flask with 50 ml of sample or an aliquot diluted to 50 ml with distilled water. Mix in 5 ml of sulfuric acid reagent, 1 gram of $HgSO_4$, and a few glass beads before cooling. Mix with 25 milliliters of 0.0417 M $K_2Cr_2O_7$ solutions. Attach the flask to the condenser, turn on the

cooling water, then swirl and mix in an extra 70 ml of sulfuric acid reagent through the open end of the condenser.

2. After two hours of refluxing, cool, and wash the condenser with distilled water to double its volume.
3. Add two drops of ferroin indicator, titrate the remaining potassium dichromate with standard ferrous ammonium sulphate (FAS), and continue until the color changes from bluish green to reddish brown. Additionally, use reagents to titrate and reflux a blank of distilled water.
4. When analyzing very low COD samples, use standard ferrous ammonium sulphate (.025M) and 0.00414M $K2Cr2O7$.
5. Test the potassium hydrogen phthalate solution to assess the methodology and reagents.

Calculation:

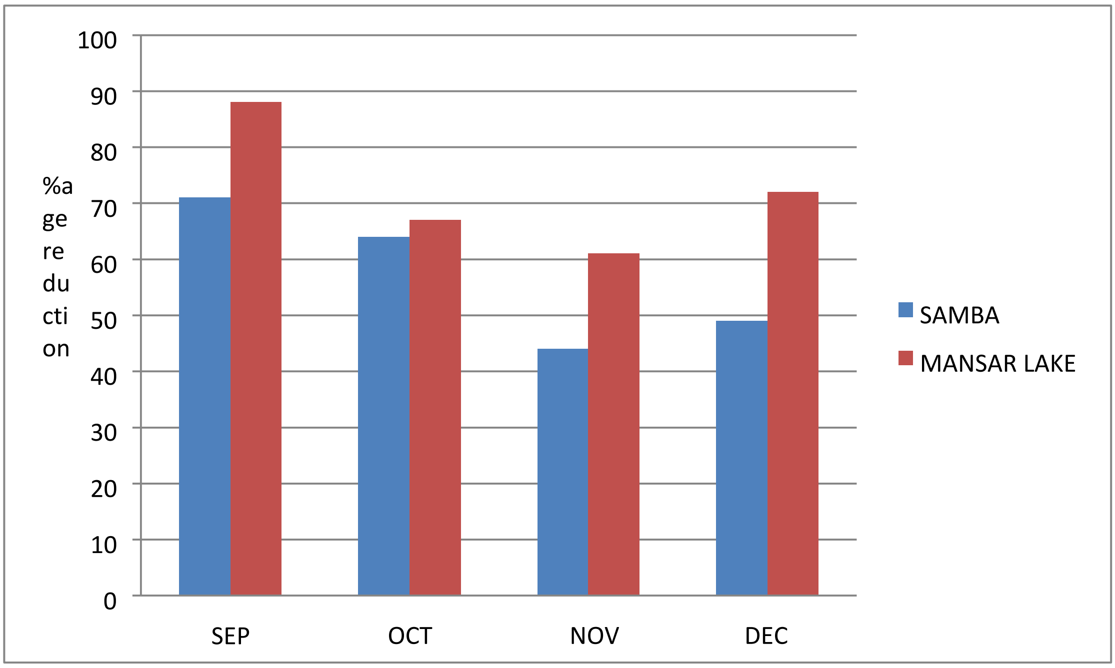
COD (mg/l) = [(A-B)*M8000]/ml of sample

A=FAS used for blank (ml) B=FAS used for sample (ml)

M=Molarity of FAS.

Table 5.3:- Observations for COD test between Samba & MANSAR LAKE

SAMBA S.T.P. (FAB)				MANSAR LAKE S.T.P. (SBR)			
Date of sampling	Inflow (mg/l)	Outflow (mg/l)	%age reduction	Date of sampling	Inflow (mg/l)	Outflow (mg/l)	%age reduction
16/09/19	114	32	71	20/09/19	224	30	86
20/10/19	130	46	64	25/10/19	288	96	67
25/11/19	128	71	44	30/11/19	224	86	61
15/12/19	132	67	49	15/12/19	270	74	72



Graph 5.3- Comparison of %age reduction in COD between Samba and MANSAR LAKE

5.4 AMMONIA, NITROGEN

METHOD; DISTILLATION TITRIMETRIC [31]

PROCEDURE;

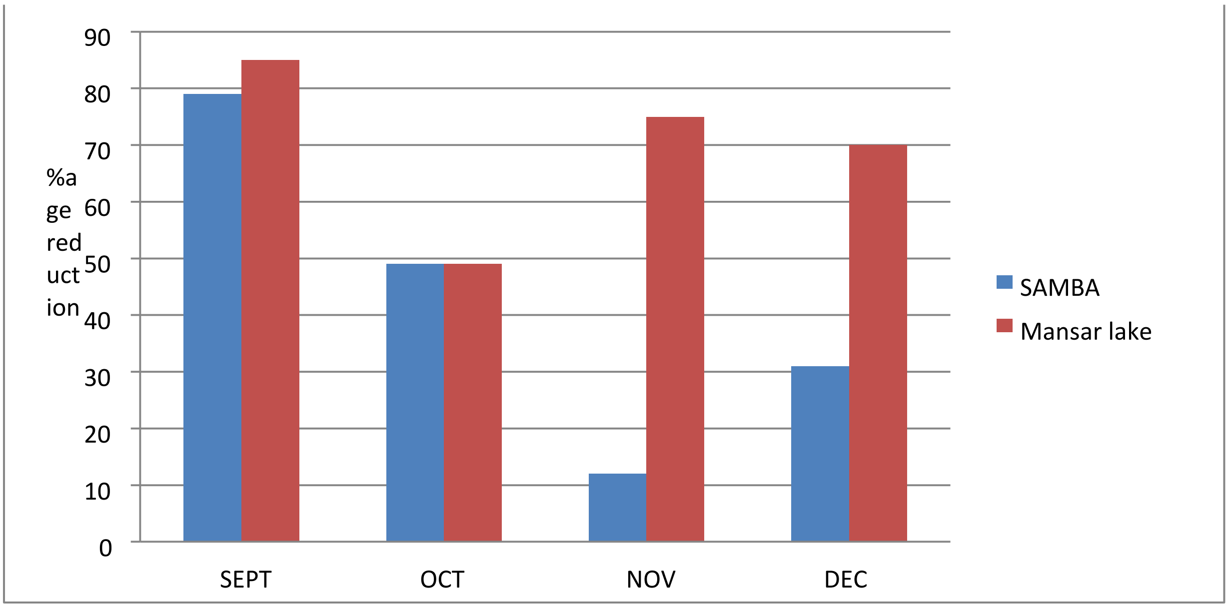
1. Boil distilled water in the ammonia distillation device to remove any remaining ammonia. Make use of a liter Kjeldahl flask.
2. Transfer 500 milliliters of the sample into the flask after emptying it. if a reduced sample size is employed. Refill with 500 milliliters of ammonia-free water.
3. To a 200 ml volumetric flask, add 10 ml of the phosphate buffer solution and distil until about 200 ml are collected. (The residue can be utilized for the assessment of organic nitrogen in either case.)
4. Add ammonia-free water to make up the distillate to 200 ml and well mix. Pour a measured amount into a 100 ml Nessler tube using a pipette, then top it off with ammonia-free water. A trial is necessary to determine the necessary volume. Use a volume that will fall into the range if the color this volume in step no. 7 produces is outside of the acceptable range.
5. Fill 100 ml Nessler tubes with 0.2, 0.4, 0.6, 0.8, 1, 1.4, 1.7, 2.5, and 3 ml of standard ammonium chloride solution to create temporary standards. Adjust the dosage using water free of ammonia.
6. Fill the sample (and each temporary standard, if applicable) with 2 ml of Nessler reagent. Let it stand for 10 minutes, then compare the colors. Note which standard's color is closest to the sample's.

CALCULATIONS;

ML of Standard NH4CL*2000/ML used in step 5* ml of sample = ppm. ammonia nitrogen Observations for ammonia nitrogen test:

Table 5.4 :- Observations for AMMONIA NITROGEN between Samba & Mansar Lake

SAMBA S.T.P. (FAB)				BRARINAMBAL S.T.P. (SBR)			
Date of sampling	Inflow (mg/l)	Outflow (mg/l)	%age reduction	Date of sampling	Inflow (mg/l)	Outflow (mg/l)	%age reduction
16/09/19	2.8	0.6	79	20/09/19	3.4	0.5	85
20/10/19	16.7	8.6	49	25/10/19	3.3	1.7	49
25/11/19	10.9	9.6	12	30/11/19	14.2	3.2	75
15/12/19	12.3	8.5	31	15/12/19	14.3	4.2	70



Graph 5.4- Monthly variations in %age reduction of ammonia nitrogen in 2019

5.5 TOTAL PHOSPHORUS:

Phosphorous chemicals are comparatively abundant in waste water. A nutrient called phosphorus is needed by organisms to flourish. It happens naturally in water where waste binds to oxygen to create phosphates[31]. There are many different sources of phosphates, such as geological formations, detergents, household water, industrial process waste, and agricultural fertilizers. When phosphorus-containing waste water is released, algae may proliferate to the point that drinking water supplies develop taste and odor issues. Fish and other aquatic organisms in streams may perish as a result of oxygen deficiency brought on by dead and decomposing algae. Because of this, phosphorus removal is a crucial function of waste water treatment facilities, and phosphorus in plant effluent testing is vital.

DESCRIPTION OF DIGESTION STEP

Pre-treatment techniques have been devised to convert the many forms of phosphate phosphorous to the orthophosphate form since waste water samples include phosphorus in multiple diverse forms, and the approved test method only measures the orthophosphate form. The sample is digested to simultaneously convert the polyphosphate and the organic phosphate to the ortho form if the total phosphate phosphorus is the sole measurement that needs to be made. Should the analyst be required to test for different types of phosphate and carry out acid hydrolysis. This is not included in the test because most institutions do not require it. [31].

LABORATORY PROCEDURE FOR DI/GESTED SAMPLE:

1. Use distilled water to dilute a suitable amount of sample to 50 ml, then measure it.
2. Add phenolphthalein indicator in one drop. Add sulfuric acid solution until the color simply vanishes if a reddish tint arises.
3. Add 0.4 grams of ammonium per sulphate and 1 milliliter of sulphuric acid solution.
4. Simmer for 30 to 40 minutes, or until 10 milliliters is the whole volume.
5. Once cool, add one drop of phenolphthalein and use one nickel sodium hydroxide to neutralize it to a light pink color. Up to 50 milliliters of distilled water
6. Distilled water to a volume of 50ml. Next, the digested sample is examined.

LABORATORY PROCEDURE:

1. Fill a 125 ml Erlenmeyer flask that has been dried and acid washed with 50 ml of pipette, or an equivalent amount diluted to 50 ml of digested sample.
2. Include one drop of the indicator phenolphthalein. If a red tint forms, add 5N sulfuric acid until the tint goes away.
3. Include 8ml of the mixed reagent and fully stir.
4. Give the color to develop for at least 10 minutes.
5. Use a reagent blank to zero the spectrophotometer and measure absorbance at 880 nm. 50 milliliters of distilled water are used to create the reagent blank, which is then sent through the ascorbic acid method and digesting phase. Create a sample blank from highly colored or turbid samples by mixing all of the reagents with the sample, excluding the potassium antimonial titrate and ascorbic acid. Take this blank's absorbance and subtract it from the sample's absorbance.
6. Determine the concentration by comparing the sample absorbance to the calibration curve. Adjust for dilution.

CALIBRATION CURVE:

It is necessary to build a standard curve showing absorbance vs. known phosphate concentration since the phosphate concentration is determined as a function of absorbance. The identical digesting techniques are applied to a blank of distilled water and six standard phosphorus concentrations as they are to the samples[30]. Plotting absorbance vs. phosphate concentration with these six data results in a straight line that passes through the origin.

Make six 5 mg/l phosphate dilutions to yield the following final concentrations:

Final conc.	Volume of std.	Final vol. in flask
0.1 mg/l	1 ml	50.0 ml
0.2 mg/l	2 ml	50.0 ml
0.4 mg/l	4 ml	50.0 ml
0.6 mg/l	6 ml	50.0 ml
0.8 mg/l	8 ml	50.0 ml
1.0 mg/l	10 ml	50.0 ml

It is necessary to build a standard curve showing absorbance vs. known phosphate concentration since the phosphate concentration is determined as a function of absorbance. The identical digesting techniques are applied to a blank of distilled water and six standard phosphorus concentrations as they are to the samples[30]. Plotting absorbance vs. phosphate concentration with these six data results in a straight line that passes through the origin.

Make six 5 mg/l phosphate dilutions to yield the following final concentrations.

CALCULATIONS:

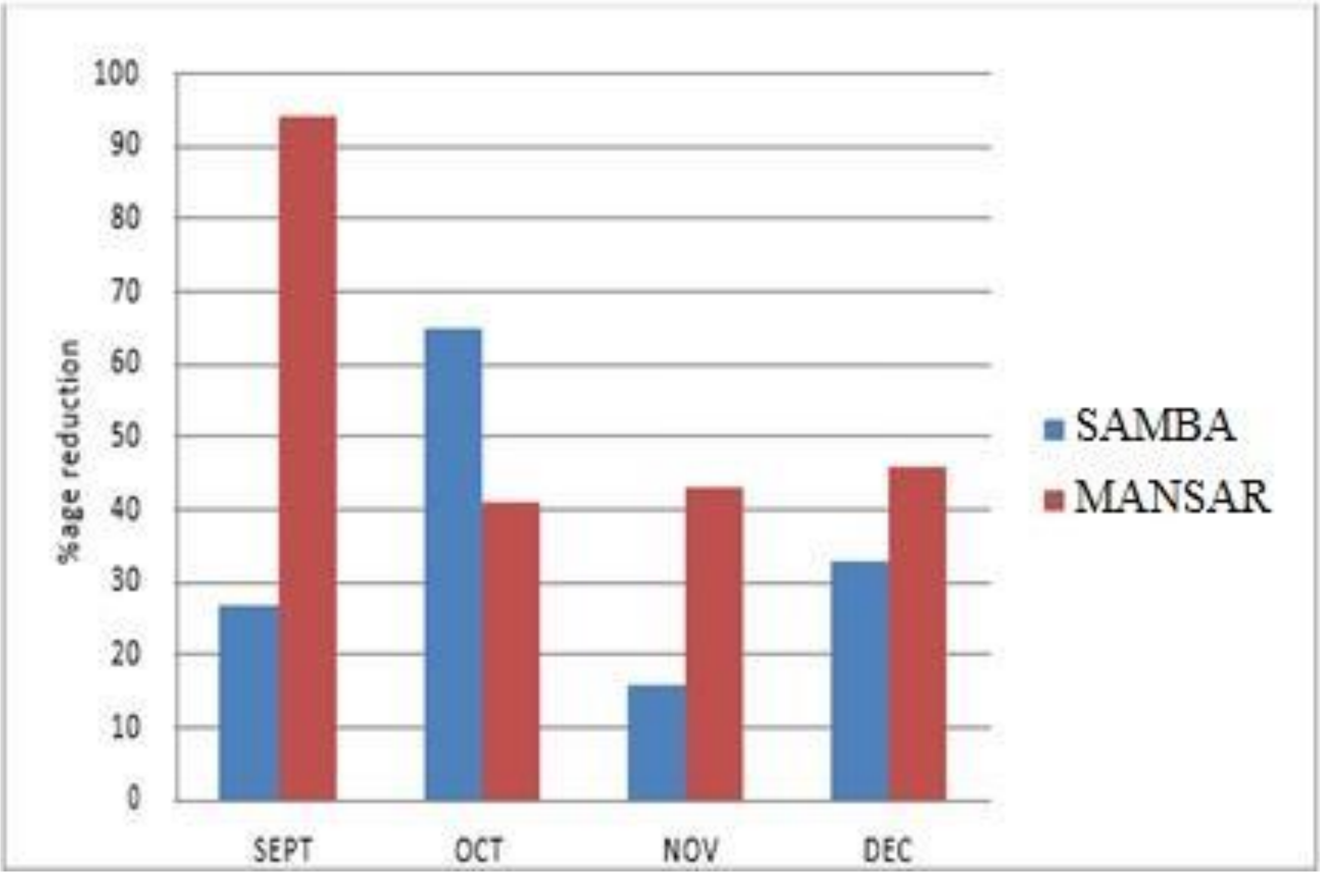
Determine the final concentration of the sample using the following equation:

P (Mg/l) = (mg/l from the curve *50ml) /(initial volume used in ml)

Table 5.5 Observations of Total Phosphorus test in SAMBA&BRARINAMBAL S.T.P

SAMBA S.T.P. (FAB)	BRARINAMBAL S.T.P. (SBR)

Date of sampling	Inflow (mg/l)	Outflow (mg/l)	%age reduction	Date of sampling	Inflow (mg/l)	Outflow (mg/l)	%age reduction
16/09/19	18.4	13.6	27	20/09/19	2.6	0.2	94
20/10/19	2	0.7	65	25/10/19	1.7	1	41
25/11/19	1.2	1	16	30/11/19	4.6	2.6	43
15/12/19	1.5	1.0	33	15/12/19	5.0	2.7	46

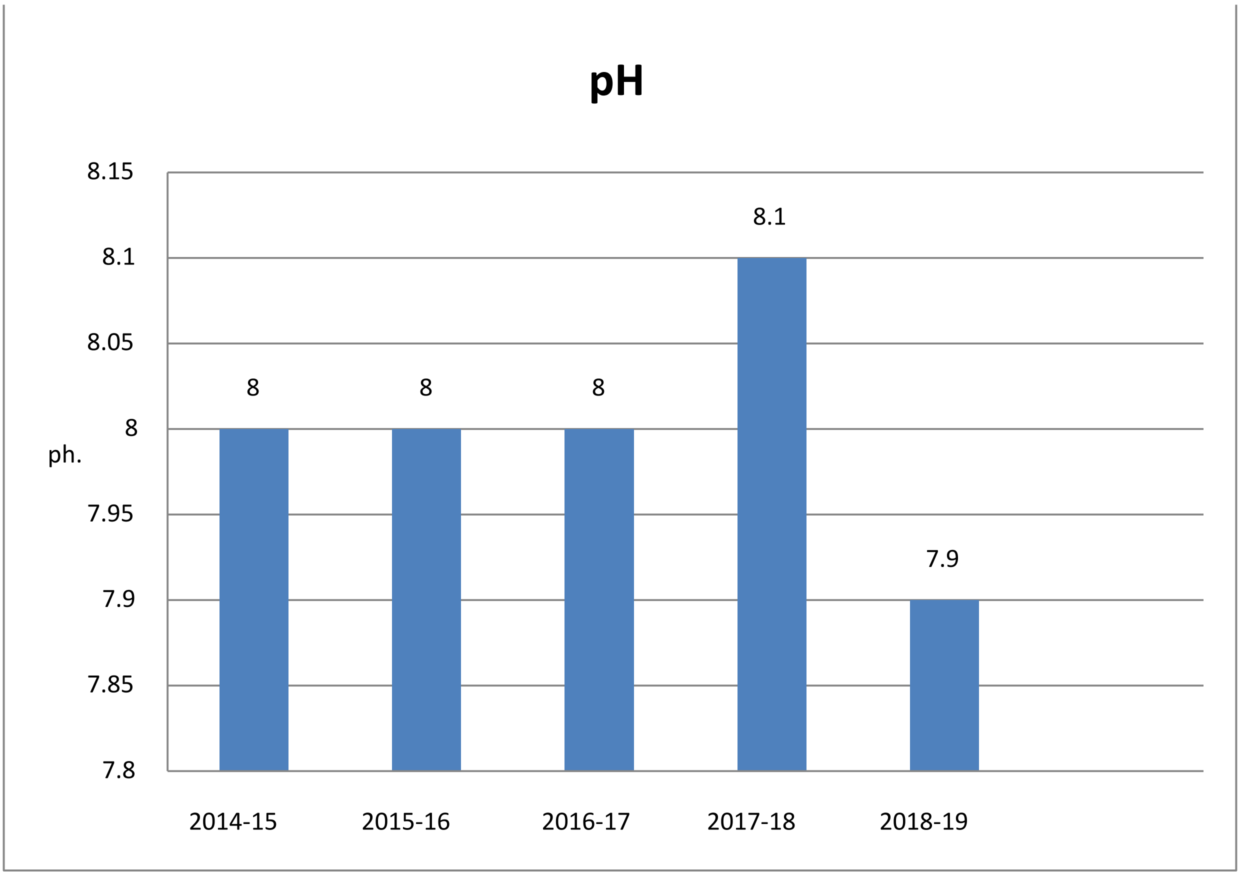


Graph 5.5- Monthly variation of % reduction of phosphorus content

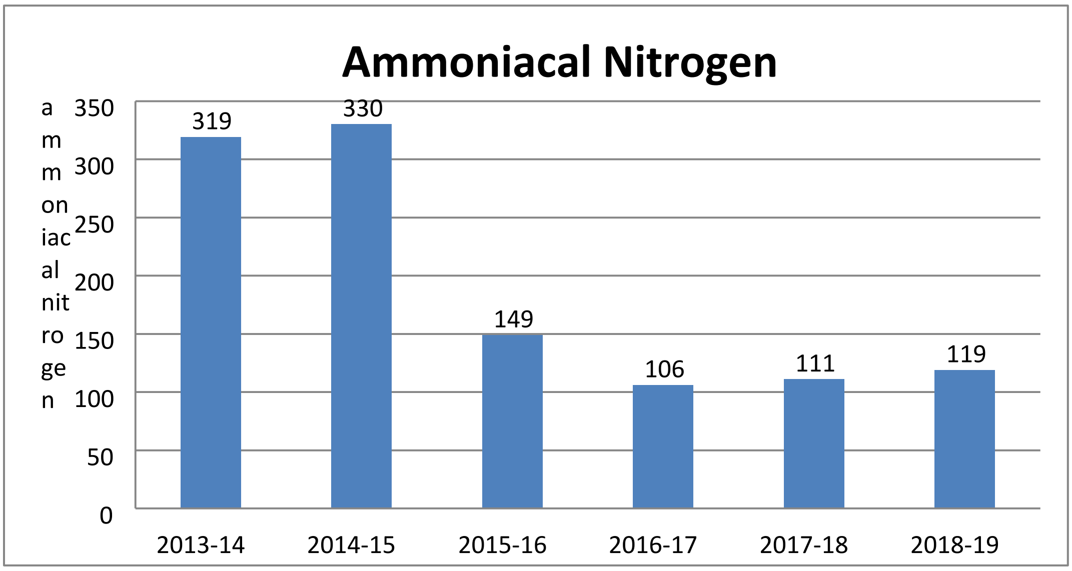
5.6 Yearly comparison of water quality parameters of Mansar Lake given by DIRECTORATE OF TOURISM JAMMU

Table 5.6.1; Comparison of average water quality parameters of Mansar Lake in previous years

Year	pH	Ammoniacal Nitrogen (mg/l)	BOD (mg/l)	COD (mg/l)	Total phosphorus (mg/l)
2014-15	8.0	6.1		25	360
2015-16	8.0	6.0		29	410
2016-17	8.0	5.8		27	360
2017-18	8.1	6.0		30	342
2018-19	7.9	6.2	13	32	534



Bar chart 5.6.1 Showing yearly variation of pH in Mansar Lake



Bar chart 5.6.2 showing yearly variation of Ammoniacal Nitrogen in Mansar Lake

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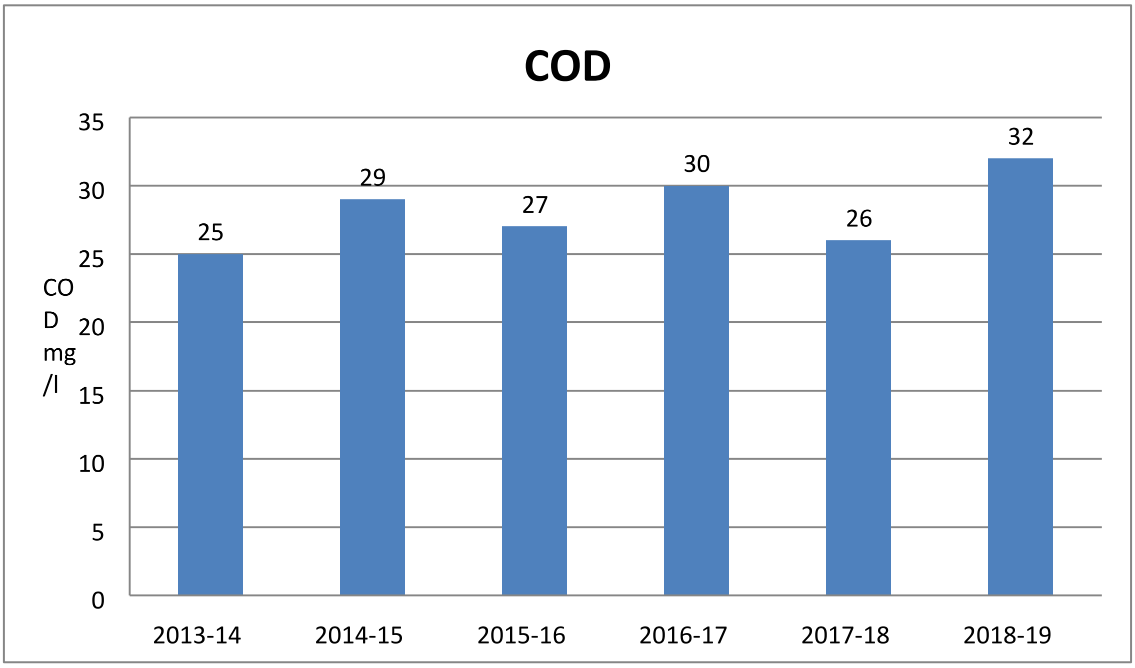
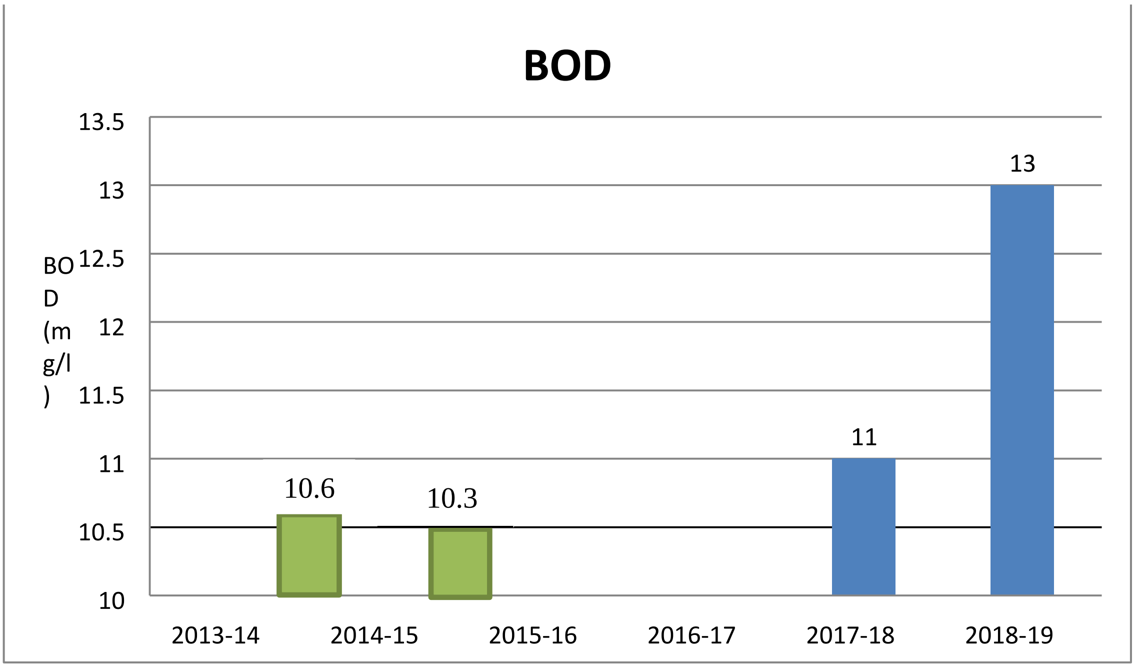


Bar chart 5.6.3 Showing yearly variation of total phosphorus in Mansar Lake



Bar chart 5.6.4 Showing yearly variation of BOD in Mansar Lake

Table-5.6.2 Physico-chemical characteristics of Mansar Lake in various year

Basin	year	Air temp(°C)	Water Temp(°C)	pH	Specific Conductivity (µ at 25 °C)	Dis. Oxygen (mg/ltr)	Silicate (mg/ltr)	Alkanity (mg/ltr)	Nitrate Nitrogen (mg/l	Phosphorous (mg/ltr)	Ammonical Nitrogen (mg/ltr)

									tr)		
Samba	2016, 2019	18.2, 18.8	16.4, 15.4	7.8, 7.5	394, 422	7, 6.5	4, 3.6	102, 105.2	507, 665	504, 583	366, 345
Udhampur	2015, 2016	18.5, 23.8	16.6, 16.1	8.1, 7.8	277. 296	7.3, 7.8	3.1, 3.5	56, 45	456. 493	507. 608	263. 223
Dayala chak	2016 2019	17.2, 16.8	15.3, 15.7	8, 7.8	486 .537	6.5, 6.2	4.2, 4.5	125, 126.5	442, 582	570. 532	461 348
Kathua	2016, 2019	19.4, 22.8	17.4, 18.1	7.9, 7.2	333, 386	6.4, 6.1	3.8, 4	87. 84.8	752, 535	535, 521	662, 698
Mansar Lake	2016	16.75	13.50	7.60	223	4.94	5.70	156.	406	145	125
Samba	2018	-	-	6.4	527	6.6	-	170	18	-	-
Udhampur	2018	-	-	4.5	289	5.8		170	16	-	-
Dayala chak	2018	-	-	6.9	471	6.6	-	180	20	-	-
Kathua	2018	-	-	7.1	252	7.5	-	110	21.33	-	-
Mansar Lake	2018 to 2019	19.85	15.6	8.45	295	6.3	-	324	39	-	316

Table-5.6.2 Physico-chemical characteristics of Mansar Lake in various year

5.7. DEPLETING WATER QUALITY AND INEFFICIENT STP'S

In the previous 20 years, the lake, which formerly spanned 75 square kilometers, has reduced in size to 12 square kilometers. The lake's depth has also decreased by almost 12 meters, which is a serious indicator of the risks the lake confronts. The Lakes and Waterways Development Authority (LWDA) estimates that around 80,000 tons of silt, 31,000 kg of nitrates, and 4,000 kg of phosphates are added to the lake each year, making the numbers from the Mansar Lake pollution statistics look dire. People who live near the lake have suffered from gastrointestinal illnesses during the last thirty years as a result of the nitrate and phosphate loaded water[32]. The local population's involvement has resulted in significant harm to the Mansar Lake. On the surface of the Mansar, houseboats are inhabited by about 7,500 people. The neighboring small islands are home to about 50,000 people, and it is inevitable that their domestic trash ends up in the Mansar. The lake's water quality has been seriously compromised by ongoing garbage disposal. The water's oxygen content has decreased from 10.2 mg/liter to 6.8 mg/liter. Phosphorus and nitrogen, two dissolved solids, have grown in concentration from 30.2 mg/litre to 200 mg/litre. The water in some areas of the lake has turned green due to algal development. Unfortunately, the pollution issue surrounding Mansar Lake has not been greatly helped by sewage treatment plants, or STPs, which are essential for the treatment of sewage. According to a July 2019 estimate by JAMMU's Lakes and Waterways Development Authorities (LWDA), around 25 million liters of sewage per day, of which 20 million liters are untreated, enter into Mansar Lake. Out of the five STPs in JAMMU, three have reached their limit. The lake is being severely hampered by the STPs' incapacity to handle more than 30 million liters of sewage per day (MLD).

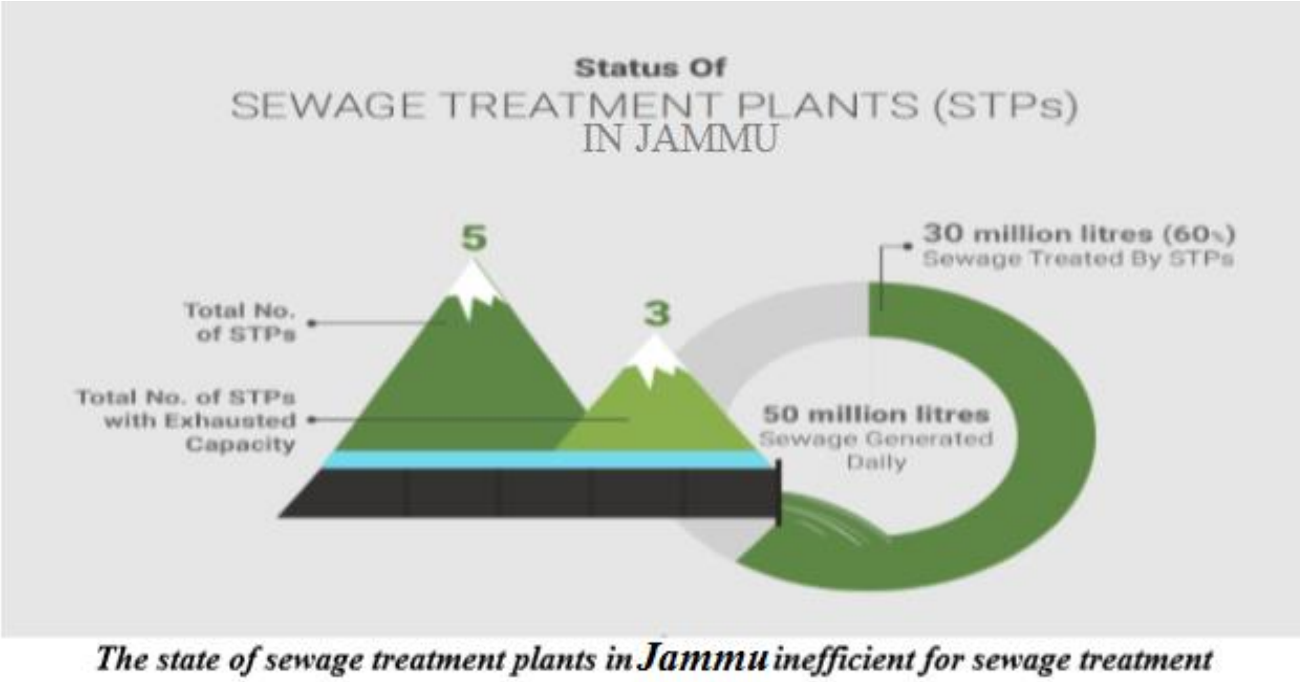


Figure 5.7.7 shows The State Sewage Treatment In Jammu

5.8 SUGGESTIVE MEASURES

- Conservation of catchment areas by afforestation and soil preservation
- Basin for settling
- Dredges on the margins of Samba and Mansar Lakes Sinks
- Dredging in townships
- Purchasing properties and buildings inside the lake
- Selective skimming and deweeding
- Systems of peripheral wastewater for Mansar Lake.
- Cheap sanitation in the vicinity of Mansar Lake.
- Sanitation of house boats.
- Handling of solid waste.
- Natural boundaries and protective areas.
- Foreshore road in the north.
- Pedestrian mall on the western foreshore.
- Paved embankment to mark the Mansar Lake boundary
- Enhancement of gated regulators and water circulation
- Enhancement of the Nallah Amir Kahn outflow canal Enhanced navigational paths
- Dewatering station situated between Telbal and Nishat
- Studies on biomonitoring and water quality monitoring, encompassing fisheries and modeling
- Public awareness and community involvement
- The construction of administrative buildings, labs, and other infrastructure .

- Reduced quantity of STPS

The restoration measures should lay emphasis on: SUGGESTIVE MEASURES: -

1. Catchment conservation, in which action should be made to reduce soil erosion and manage flow regimes in micro watersheds that have already been identified and given priority.
2. Integrated water management with restoration, whereby actions should be taken to improve the area under willow plantations, water lilies, vegetable gardens, and other encroachment; improve the water holding capacity based on water and sediment balance; and take appropriate action to improve the water quality.
3. Conservation of biodiversity, which entails increasing the diversity and quantity of schizothorax and restocking certain native and endemic fish populations to the point of self-sufficiency. Additionally, focus should be placed on creating a strategy to slow the rapid growth of invasive and endemic aquatic plant species including lemna, Salvinia, and Azolla.
4. Deweeding with mechanical tools like harvesters and truxors involves mass weed selection rather than appropriate weed selection to be regulated, which could eventually cause irreversible damage to the lake's biotic structure. As a result, further scientific deweeding methods that concentrate on population density and dispersion pattern are required.
5. The long-range fix.We believe that the implementation of a tried-and-true Root Zone technology (Treatment compartments) for wastewater treatment is the solution to the issue in Jammu, where there is already an energy crisis and harsh summers. In addition to other chemical components, it has been discovered that the treatment compartments are effective at reducing nutrients (phosphorus by 73%) and nitrogen by 70%. When compared to traditional secondary and advanced wastewater treatment systems, the construction of treatment compartments for wastewater treatment in and around Mansar Lake, as well as other lakes in the Jammu valley, will have several advantages and can help to maintain the current trophic status of the water body.
6. A rapid increase in the number of STPs in the vicinity of each basin and potential contamination sources

5.9 CONCLUSION AND FUTURE SCOPE

The study's findings indicated that the Samba sewage treatment plant's efficiency rate fell short of both national and international norms, making it inappropriate to dump its effluent into the lake before thorough disinfection[31]. To improve the removal efficiency of this STP, it is also advised that authorities use tertiary treatment procedures such UV disinfection, artificial lagoons, wetlands, sufficient contact time, and fast sand filtering. To make sure that rigorous adherence to effluent discharge requirements is fulfilled, it is also advised that wastewater effluents be routinely monitored. Thus, it can be said that Brarinambal Sewage Treatment Plant (SBR) has a higher efficiency rate than Samba S.T.P. (FAB), but neither S.T.P. reaches the required level; hence, the J&K government ought to take preventative action to preserve Mansar Lake. To address the threat of ongoing contamination in Mansar Lake, new sewage treatment plants and point source outlets are urgently needed. Numerous sources emerged during the study, including the direct pollution caused by houseboats, unauthorized occupants, unmonitored sewage pipelines, ineffective solid waste disposal in the surrounding area, and the area's dense population of hotels and homes. Additionally, non-point sources—particularly nutrient enrichment—contribute to pollution because of Mansar Lake's wide spatial range. The effectiveness of the two sewage treatment plants and the chemical analysis of the lake's waters provide important insights into Mansar Lake's issues and potential sources of pollution. upcoming In general, Mansar Lake treatment options range from biological to physical-chemical treatment methods, provided that the waste produced by each process has the same characteristics.This is untrue, though, in the case of tourism and regular trash[32]. This is because different types of pollutants are often dumped in the vicinity of the lake, and new technologies are being overseen to improve the lake's condition. As a result, different government authorities are controlling the variation in both quantity and quality of pollution.

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