

Sewage Fed Fish Culture

Definition of Sewage

Sewage is defined as a cloudy fluid arising out of domestic, municipal and industrial waste, containing mineral and organic matter in solution or having particles of solid matter floating, in suspension, or in colloidal and pseudo-colloidal form in a dispersed state. Sludge differs from sewage in that it is the solid portion of waste and does not include fecal matter urine.

Composition of Sewage

Sewage may vary considerably in composition and strength from place to place owing to marked differences in the dietary habit of the people, composition of trade waste and water consumption. The strength of sewage is determined by the amount of O₂ required to oxidize completely the organic matter and ammonia present in it. There is also variation in composition between domestic and industrial sewage, the later containing more pollutants in terms of heavy metals and bacterial load and other toxic ingredients. While the sewage is very rich in anaerobes when it is raw but gradually transforms to an enriched freshwater when it undergoes treatment. Sewage contains living matter especially bacteria and protozoa. The water content of sewage may be 98 – 99.9 %, rest being dry solid matter. Domestic sewage has been reported to contain about 250 – 400 ppm of organic carbon and 80 – 120 ppm of total nitrogen, thus giving the C:N ratio of around 3:1. Industrial sewage may contain more organic carbon and hence may have a higher C: N ratio. Nitrogen in sewage is present partly as organically bound element and partly as ammonical nitrogen.

History of Sewage Fed Fish Culture

The fish farmer of Kolkata developed a unique technique of utilization of domestic sewage for fish culture long back in 1930s. The early inspiration of utilizing the sewage for fish culture emerged from the waste. Stabilization pond used as water source of vegetable fields. This technique is considered to be the largest operational system in the world to convert the waste in consumable product. The growing fish demand of the metro city Kolkata is widely met by this technique.

Present Status of Sewage Fed Fish Culture

In the course of time the area under sewage-fed fish culture reached up to 12,000 ha. But recently due to rapid and indiscriminate urbanization it has come down to 4,000 ha.

(approx) resulting in crisis of livelihood of rural people. There are appeals to Government to declare the existing sewage-fed aquaculture area as sanctuaries.

Treatments of Sewage

1. Primary treatment

This is mostly the physical removal of solids by mechanical means. The solid material is removed by screening (for larger coarse particles), skimming (for floating solids) and sedimentation (for suspended particles whose density is greater than that of liquid) techniques.

2. Secondary treatment

Soluble organic and inorganic matter, namely the carbohydrates, proteins, fats, hydrocarbons and other nitrogenous materials which are degraded mostly biologically, using microorganisms into the smaller constituents i.e. CO_2 , H_2O , NO_3 , NO_2 , SO_4 , PO_4 etc. which can be easily disposed. Sometimes chemical and physical removals of substances are combined with this to increase the effectiveness. There are three basic methods for secondary treatments:

- *Activated sludge (flocculation)*
- *Biological filtration*
- *Waste stabilization*

In the activated sludge or flocculation process, the sewage is aerated by diffused air or by mechanical means. The activated sludge (or biological floc) contains the microorganisms that remove the soluble and insoluble organic matter in the sewage by a combination of adsorption and oxidation or assimilation. Aeration supplies the sludge microorganisms with oxygen and keeps the floc in suspension. After a suitable contact time (1 – 20 hrs) the sludge is separated from the sewage effluent in a settling tank. Some of the settled sludge is returned for aeration along with new sewage but most of it is treated separately in a sludge treatment plant.

3. Tertiary treatment

This is biological and chemical removal of soluble products of partial or complete oxidation. For example, removal of NO_3 , NO_2 , SO_4 , PO_4 etc.

4. Quaternary treatment

Physical or chemical removal of refractory organic or other substances which may be unpleasant and even toxic. Chemical treatment comprises of :

- (a) Coagulation or chemical precipitation (e.g. by alum)
- (b) Deodorization (by Cl_2 , FeCl_3)
- (c) Disinfections or sterilization (by Cl_2 , CuSO_4 , liming etc.).

The process generally adopted for the use of sewage treatment before release in fish ponds are:

- (1) Sedimentation
- (2) Dilution
- (3) Storage.

Sedimentation

The function of sedimentation is to remove suspended solids from sewage to the maximum possible extent. It is done by letting sewage into a pond/tank at a high velocity of flow. Sedimentation results due to sudden drop in velocity when sewage enters a large pond from sewage channel. Sedimentation is best carried out by in two successive stages i.e. primary and secondary. The primary stage is intended to settle down most of the heavier solids while the secondary stages serves two purposes: (a). Provision of additional period to help to mix and homogenize variations in the flow and (b). Promotion of natural purification process. It has been estimated that about 33% BOD is got rid of by sedimentation process, which may effect with 90% settlement of suspended solids and about 25% reduction in albuminoid ammonia.

Dilution and Storage

Before introduction of sewage into any fishery its dilution by freshwater should be so effected that a positive dissolved oxygen balance (1:1 or 1:2) is maintained and the concentration of unwholesome ingredients such as CO₂, H₂S, NH₃ etc. kept below lethal limit. The oxygen required for biochemical reaction is obtained from fresh water used for dilution and through green algae, and other vegetation in the water body. Sewage is stored here for few days. During storage, the biological processes carried out by microorganisms present in the raw sewage oxidize it.

Use of oxidation ponds (waste stabilization ponds) for sewage-fed fish culture has been suggested by many several workers. *The term waste stabilization ponds is applied to a body of water artificial or natural employed with the intention of retaining sewage or organic waters until wastes are rendered inoffensive for discharge into receiving waters or on land through physical, chemical and biological process (self-purification).* This pond is suitable in India because of plentiful of sunshine. These are also cheap to construct and easy to operate. Organic matter contained in the waste is stabilized and converted in the pond into more stable matter in the form of algal cell, which find their way into the effluent. These ponds are of three types:

i). Anaerobic ponds

It is pre-treatment digester and requires no dissolved oxygen. These are designed to take on higher organic loading so that anaerobic condition prevailed throughout the pond. Such ponds are 2.5 – 3.7 m deep. Ends products are CH₄, H₂S, NH₃.

ii). Aerobic ponds

These are shallow, depth is 0.3m or less, so designed that growth of algae through photosynthetic action is maximized. Waste material is stabilized through microorganisms only and aerobic condition is always maintained. Ends products are CO₂, H₂O, NO₃, SO₄, PO₄ etc.

iii). Facultative ponds

These are 0.9 – 1.5 m deep and are aerobic during day hours as well as for some hours at night. Only for few remaining hours of night, bottom layer become anaerobic. Aerobic, anaerobic and facultative may all be found in a facultative pond. In India, most of the waste stabilization ponds are of facultative type. The village ponds and natural depressions in rural areas are example of waste stabilization ponds.

Technologies adopted by farmers

The sewage fed ponds are locally known as **BHERIES**. These are the ponds of different sizes, which can be as big as 40 ha. The ponds are shallow with a depth ranging from 0.5 to 1.5 m. Generally the culture practice includes five phases:

1. Pond preparation.
2. Primary Fertilization.
3. Fish stocking.
4. Secondary fertilization (Periodic)
5. Harvesting of fish.

Pond Preparation

Pond preparation is undertaken generally in winter (Nov – Feb) when the fish growth is reported slowest. Ponds are drained, desilted, tilled and dried in sun. The pond dikes are consolidated. Silt traps (perimeter canal along the dikes) 2-3 meter wide and 30-40 cm. deep are dug, as they get filled during regular harvesting of fishes. Aquatic weeds as water hyacinth (*Eichhornia*) is grown along the pond dikes, which save the dikes from wave, and give shelter to fishes against high temperature and poaching and above all it extracts heavy metals from the sewage, supplies oxygen by photosynthetic activity. The bamboo sluice gate is repaired which helps to prevent the entry of unwanted fishes and escape of cultured fishes.

Primary Fertilization

After pond preparation, sewage is passed in to the pond from the feeder canal through bamboo sluice. It is left to stabilize for 15 – 20 days. The self-purification of sewage takes

place in presence of atmospheric oxygen and sunlight. When the water turns green due to photosynthetic activity, the pond is considered ready for stocking. **Fish Stocking**

All the species of Indian major carps e.g. *Labeo rohita* (Rohu), *Catla catla*, *Cirrhinus mrigala* (Mrigal) and Exotic carps e.g. *Hypophthalmichthys molitrix* (Silver carp), *Ctenopharyngodon idella* (Grass carp), *Cyprinus carpio* (Common carps) are preferred to be stocked but the percentage of Mrigal is kept greater and that of exotic carps is lesser. The popularity of *Talapia* and fresh water prawn, *Macrobrachium rosenbergii* is increasing these days. *Pangasius hypophthalmus* is also stocked by some farmers to get rid of mollusks. As the sewage contains high content of nutrient, the farmers keep very high stocking density, i.e. 40,000 to 50,000 fingerlings/ha.

Secondary Fertilization (Periodically)

After stocking, sewage is taken in ponds throughout the culture period at regular intervals @ 1 – 10% of the total water volume of the pond. In bigger ponds, water level is maintained by continuous inflow and out flow. The requirement of sewage is determined by observing the water colour, transparency, temperature and depth. **Feeding of stocked fishes**

Due to high contents of nutrients in sewage, the cultured fishes don't require at all any supplementary feeding. However, occasionally, especially in rainy season when the potential sewage is lacking, they are fed with supplementary feed.

Health care of fishes

The fishes are most vulnerable to bacterial diseases, but surprisingly the occurrence of bacterial or any other disease is not common in sewage-fed fish farms. Even when EUS was prevailing in past years in other areas, the sewage-fed ponds were uninfected. However, parasitic infections by *Lernea* (Anchor worm) and *Argulus* (Fish lice) are common but they are not given any proper treatment. There is a need to develop a technique to keep these problems aloof.

Harvesting (in rotational manner with stocking)

The *BHERI* farmers have evolved rotational cropping system to maintain the supply to the market. Fishes are stocked and harvested throughout the culture period leading to periodical stocking and regular harvesting. After completion of one phase, fishes are restocked @ 1 Kg fingerlings per 5 kg harvested fish. Another harvest phase starts after 15 days of restocking. Generally, drag nets are used for harvesting by encircling technique. Some fishes like *Tilapia* and Common carp require hand picking technique for their harvesting. Specialized fishermen are employed in fishing.

Advantages of sewage-fed Fish culture

- No manuring and supplementary feeding is required due to high content of nutrients in sewage.

- Input cost is very low (only in fish seed) and production is very good.
- This is the biological method of treating the waste water especially municipal sewages before its final disposal in river.
- It reduced the pollution load of river and in the aquatic ecosystems.
- It produces animal proteins i.e. fish at cheaper rate and contributes towards food security. 6. The bherries and ponds in which fishes are cultured act as water harvesting structures.
- The process recharges the ground water and saves the big city from drying and collapse. The buildings, other establishments & structures above the surface layers of soil may collapse when the underground water column is dried and a vacuum is created below the soil layer.
- It generates income and lakhs of families manage their livelihood from it.

Negative aspect of sewage fed aquaculture – Use of Raw sewage

- The sewage contains high load of organic and inorganic matters, toxic gases but its dissolved oxygen contents is very low.
- As the raw sewage is used in fish ponds, there is a chance of infection and pollutions to enter into human body through fish. But this risk can be minimized if good managerial practice is followed, e.g. - Use of treated sewages for fish culture instead of raw sewage. - Keeping the fish for 3-4 weeks in marketing pond (Clean fresh water pond) before marketing.