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CARP PRODUCTION USING DOMESTIC SEWAGE

PACKAGE OF PRACTICES FOR INCREASING PRODUCTION

CIFRI

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FOREWORD

With the continuing increase in population size of the country which has already crossed 700 million and various developmental measures leading to urbanisation, development of towns and cities along the river banks and estuaries the country's rivers are already showing ecological perturbation from the large scale sewage effluxion. There is growing awareness among planners, administrators and ecologists on the need to re-cycle sewage waste into the protein wealth. Such efforts are already underway for River Ganga where the sewage of towns and cities along the river banks is expected to be diverted into productive processes. Sewage waste water provides scope for large scale culture of protein-rich algae at primary treated level and fish at the secondary treated level to reduce BOD, improve water quality, besides generating protein fish wealth. It is against this context, CIFRI took up detailed studies in evolving suitable technologies for culture of carps and giant freshwater prawn in the sewage fertilised ponds. An average production to the tune of 7,000 kg/ha/yr using selected major carps and 500 kg/ha/8 months for giant freshwater prawn without feed or fertilisers has been achieved. The manual sets forth a set of package of practices for optimum production of fish and prawn in sewage-fed ponds. The manual has been designed for use by extension workers, entrepreneurs, bank officials, ecologists and municipal authorities.

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PACKAGE OF PRACTICES FOR USING DOMESTIC SEWAGE IN CARP PRODUCTION

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1. INTRODUCTION

Waste water produced in a community is looked upon today as the residue of resources that the community has metabolised. The approach towards waste water disposal should be utilization of this residue with the concept of their reuse or recycle through an ecologically balanced system involving mainly aquaculture and agriculture. The utility of sewage effluent to enhance fertility of freshwater ponds has long been known in many countries of the world. The'average annual production of carps from sewage enriched waters in Germany, Rumania, Poland, Hungary, Israel, China and Java is estimated to vary between 3 and 4.5 tonnes/ha.

In India, there are over 132 sewage-fed fish farms covering an area of 12,000 hectares and almost all of them are fed with raw sewage for fertilization. The Vidyadhari sewage-fed fisheries near Calcutta is an example where farmers have taken full advantage of sewage disposal system of Calcutta Corporation for developing fish culture of the area. The annual yield from these fisheries is about 1,258 kg/ha. Raw sewage is inimical to fish life for high values of BOD, OC, CO_2, NH_3, H_2S, bacterial load and negative oxygen value. The high manurial capacity combined with the potentiality to serve as an additional source of water for maintaining desired depth of fish pond for culture, particularly during dry seasons, are added advantages of using such waste waters for fish culture. For the last few years investigations on sewage fed fisheries have enabled CIFRI to develop technologies for judicious utilization of sewage effiuent through fish culture without any other additional nutritional inputs like, feed and fertilizer commonly used in freshwater aquaculture.

2. CHARACTERISTICS OF SEWAGE

Domestic sewage basically contains wastes from toilets, bathrooms, kitchens and other house-hold washings together mixed up with trade water, ground water, storm water, etc. Although there are considerable similarities in the basic constituents, the characteristics of sewage varies not only from place to place but also from hour to hour at the same place depending on the climatic conditions, availability of water, dietary habits, social customs, etc. The salient and basic features of sewage are given below.

2.1 Physical features

Sewage is a black coloured foul smelling fluid or semifluid containing organic and inorganic solids in dissolved and suspended forms carried away from residences, business houses and industrial establishments for final disposal. Generally sewage contains 90-99.9% of water and from a typical Indian urban community, per capita production of waste water is 136 litres/day. In an average, strong, medium and weak sewage contains 1200, 720 and 350 mg/l of total solid, of which 850 and 500 and 250 mg/l in dissolved state ; 350, 220 and 100 mg/l in suspended from ; and 20, 10 and 5 mg/l as settleable condition respectively.

2.2 Chemical and biochemical properties

Macronutrient levels in a typical domestic sewage show 10 to 70 mg/l nitrogen, 7 to 20 mg/l phosphorus, 12 to 30 mg/l potassium, etc. The average values of nitrogen in strong, medium and weak sewage are 40, 25 and 20 mg/l and of phosphorus 15, 8 and 4 mg/l respectively. Organic refuses in the sewage have proteins, carbohydrates and fats in varied proportions depending on nutritional status and food habits of the population. Usually organic matters in sewage have 40-50% protein comprising of several aminoacids serving as sources for microbial nutrients. Among carbohydrates, readily degradable starch, sugar and cellulose are detected.

For utilising sewage in aquaculture, the properties like the concentrations of dissolved and suspended solid, organic carbon, nitrogen and the value of BOD are essential to be recorded. However, any mixing of industrial effiuents with domestic sewage may increase the concentration of metallic ions. Usually, BOD_5, at 20°C in strong, medium and weak sewages are 400, 220 and 110 mg/l respectively.

2.3 Microbiological characteristics

Harmless and even useful non-pathogenic bacteria are present in much greater numbers in domestic sewage as compared to pathogenic bacteria comprising mostly the intestinal microorganisms found in the community producing the waste. Usual load of coliform bacteria in raw sewage ranges between 10^8 and 10^9 MPN/100 ml or above.

3. SELECTION OF SITE AND CONSTRUCTION OF SEWAGE-FED FARM

3.1 Site selection

Fish Farm in the vicinity of an urbanised area has the scope to receive domestic sewage effluents for recycling of nutrients. Hence, any suburban agglomerated area adjacent to municipal sewage treatment plant is ideal for location of a'sewage-fed fish farm. When the site is at a lower level than the treatment plant, the sewage effluent is easily drained to the farm through a pipeline by gravity flow. In case of untreated sewage, the effiuent is brought to the farm site through a drain and then, treated in the waste stabilization pond of the farm. Farm site should have facilities of draining out water from the ponds as and when required for effective management.

3.2 Farm construction :

There is no single ideal design of a farm that can be advocated for adoption, as the plan depends upon the source of sewage, system of culture and topography of the land. The farm needs to be constructed taking the full advantage of the available resources. Nearly 70-80% of the total area is converted into rows and arrays of pond, leaving the rest for dykes and other purposes. Rectangular fish ponds of 0.3 to 1 ha and with inside slopes of 1 : 3 for the embankment and the maximum depth of 1.5 metre at the centre serve the purpose of effective management. Ponds should be constructed in North-South direction for better areation and each pond should be provided with drainage facilities to regulate the volumes of water and sewage.

A suitable shutter with a winch is fitted in the sewage effluent drainage channel of a Sewage Treatment Plant or waste stabilization pond to raise the level of the effluent for the flow of top layer into the conveyer pipeline to reach the farm by gravity. The effiuent thus drained is collected in a sump at the farm wherefrom through a set of gravity flow sewage distribution system, the effluent is taken into the ponds and discharged from the mid-depth level through valves. Ponds are also provided with another set of distributing pipelines that runs through sub-surface of the dykes and opens through valves near the water surface of the ponds. The effluent from the sump is usually pumped into such surface distributing pipe system with the help of a non-clogging pump of 7.5 H.P.

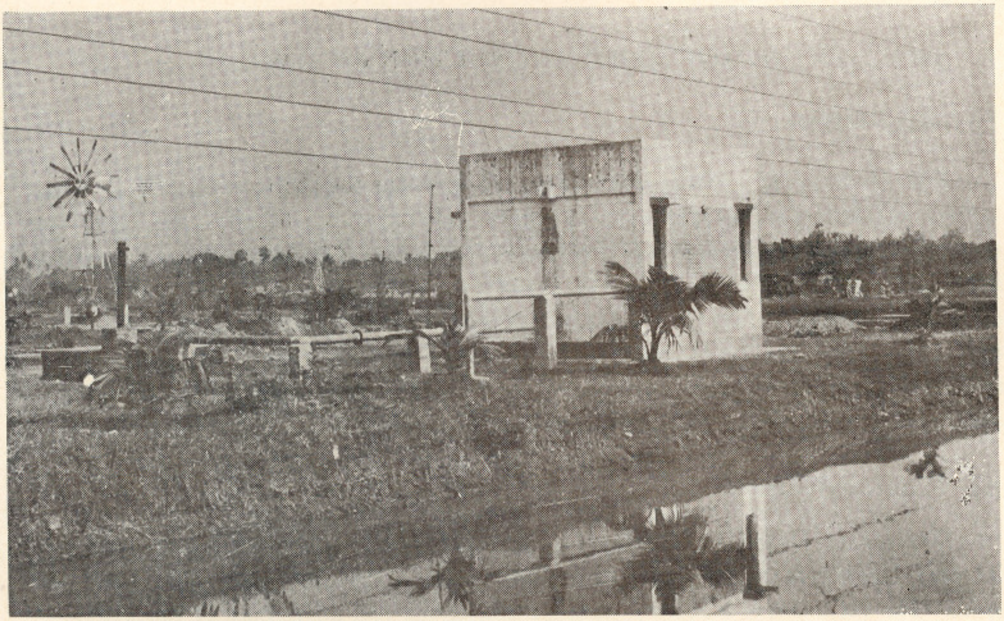

Fig. 1. *Sump and the pump house for supplying sewage to individual pond of the Rahara sewage-fed farm of CIFRI.*

Fig. 2. *Intake of domestic sewage from Titagarh sewage treatment plant for fish pond fertilization*

Additional arrangement is made to connect this sub-surface pipelines with fresh-water supply line for emergency dilution of sewage effiuent for higher oxygenation of fish pond. Drainage pipelines from the individual pond bottom converge into another sump where from unwanted water is pumped and expelled out of the farm.

4. TREATMENT OF SEWAGE

Treatment of sewage is a pre-requisite for waste water aquaculture and there are several methods of sewage treatment (both, conventional & non-conventional) known and applied at the urban centres of the country depending upon the extent of purity needed. The following treatment processes could be useful.

4.1 Primary treatment

The process includes physical and mechanical removal of solids. Usually screening and straining through grit is done to remove coarse solids. The liquid and semi-solid wastes are then subjected to mechanical charning and finally fed to a floculation tank for removal of colloidal and semisolid suspensions. Thus, through primary treatment the supernatent effluent is separated from the sludge.

4.2 Secondary treatment

The process of biological removal of soluble waste materials is known as secondary treatment. The basic methods involved in this process are activated sludge, trickling filter process, etc.

4.3 Tertiary treatments :

This method involves biological and chemical removal of soluble products.

4.4 Other treatments

Among non-conventional systems, India like other tropical countreis, has recognised waste stabilization pond method being the cheapest for conservation of nutrients and reduction of organic and bacterial loads. In some of the urban and suburban areas where waste water carriage system has been developed, waste stabilization pond system of sewage purification is also introduced to treat the additional load of sewage for disposal.

Even in small towns and prosporous villages where waste water (sewage or sullage) carriage system has been developed, it is possible to use the nutrient rich waste waters for aquaculture, primarily by sedimenting the waste water in small ponds prior to using the effluent as fish pond fertilizer. Sedimentation reduces 30-40% BOD, 90% suspended solids and about 24% albuminoid ammonia. For effective use of primary treated sewage effluent for fish culture, dilution with feshwater having normal dissolved oxygen of 4-5 ppm may be necessary to maintain a positive oxygen balance and the concentration of toxicants like CO_2, NH_3, H_2S, etc., if any, much below the lethal limits. The required oxygen for biochemical oxidation of organic matter is obtained from diluent freshwater and also through algal photosynthesis rendering the pond suitable for stocking fingerlings for culture.

5. FERTILIZATION SCHEDULE

Pond fertilization is one of the improtant aspects of fish culture. Fertilization of sewage-fed pond is done in two phases, *viz.*, pre-stocking and post-stocking phases for improving the nutrient status and natural productivity of the fish pond.

5.1 Pre-stocking fertilization

Preferably in dewatered and sun dried pond, primary treated sewage effluent is taken in up to a depth of 60-90 cm during premonsoon months *i. e.*, April-May. Effluent is then diluted with rain water freshwater or from other source till pond BOD receeds to 50 mg/1. For CIFRI ponds at Rahara, 50% dilution with freshwater having 4-5 ppm dissolved oxygen is felt necessary as the usual BOD level of the treated sewage effluent is around 100 mg/1. Soon after pre-stocking fertilization and dilution with freshwater, fish pond becomes aerobic during sunshine hours and early hours of night. But during late night, the surface water in contact with atmosphere may be aerobic but the bottom layer is usually anaerobic. Within a fortnight of fertilization, algae develop through intensification of photosysnthetic activity which helps in further lowering of BOD values to 25-30 mg/1 and in keeping DO levels greater than 2 ppm in the early monring hours and thus making the ponds suitable for fish culture.

5.2 Post-stocking fertilization

Periodic fertilization with sewage effiuent is initiated after two months of stocking to maintain the nutrient status and productivity of the pond at a desired level. When late night or early morning dissolved oxygen levels of the ponds are above 2 ppm, the intake of sewage effluent is possible to an extent which will not depelete the D O level beyond 1 ppm within 24 hours. Therefore, the quantity of sewage effluent to be allowed within a pond will solely depend on its quality determined on the basis of BOD values. Fertilization in such a rational way always keeps the pond aerobic.

5.3 Liming

Application of lime in sewage-fed pond is very useful. Apart from its usefulness as promotor of fertility in sewage-fed ponds, it acts as a disinfectant against harmful parasites causing fish diseases. Initial liming @ 200-400 kg/ha is recommended before prestocking fertilization for stabilization of the pond ecosystem, Subsequent liming @ 150-200 kg/ha on standing crop is necessary throughout the year during sewage intake and during winter months, November-February, when high intensity of parasitic infection is common.

6. STOCKING

Selection of fishes for stocking depends on commercial viability and adaptation of the species to the sweage-fed ecosystem. Since the BOD levels in fish ponds fed with primary treated sewage, are mostly below 30 mg/1 and dissolved oxygen concenttrations are maintained usually above 2 ppm, Indian major carps are considered suitable for culture in such ponds. Considering high carrying capacity and high pro-, ductivity of sewage-fed ponds in respect to plankton and benthic fish food concentration, fishes are usually stocked at a reasonably higher density. CIFRI has conducted several trials on stocking density and species ratio with a view to increasing fish production from such ecosystem. Based on such trials, the stocking rate is recommended to be 10,000-15,000/ha of carp fingerlings (10 g) and it is proferred to stock more of omnivorous scavengers and bottom feeders to maintain fish pond hygeine for higher yield. As such, ususal ratio followed for better output is Catla 1 : Rohu 2.5 : Mrigal 2.5 : Common Carp 2 : Silver carp 2. Omnivores and bottom feeders consume directly the organic detritus of sewage-fed ponds and thereby indirectly help in keeping the pond aerobic. The stocking rate of fish is kept at a higher side considering the profuse growth of algae which will otherwise grow, decay, putrify and finally deplete the oxygen concentration of fish pond. Stocking of phytophagus silver carp is, therefore, recommended to maintain positive oxygen balance in a sewage-fed pond.

7. ECOLOGICAL CONSIDERATIONS

Maintenance of aerobic condition of the sewage-fed pond is highly essential and as such early monring dissolved oxygen level should not deplete below 2 ppm for carps while BOD should be below 30 mg/l for better survival. CO_2 level should not be allowed to increase beyond 20 ppm to keep the toxicity level within tolerance limit to fish and to control algal bloom. Liming @ 150-200 kg/ha helps in regulating CO_2. Heavy metal pollution, if any, can be controlled by introducing water hyacinth at the pond margins and barricading them with bamboo poles to prevent spreading of the weed throughout the water surface and chocking the pond completely.

8. ALGAE CONTROL

Algae control is a must to maintain proper dissolved oxygen level *i. e.*, always above 2 ppm, and usually at 5-6 ppm. In carp culture system, the presence of silver carp regulates the algae. When control by biological means fails due to excessive bloom, Simazine @ 0.5-1.0 ppm is recommended for application.

9. CONTROL OF AQUATIC INSECTS

Insect fauna of sewage-fed pond mainly comprises Hemiptera, Coleoptera, Odonata, Zygoptera and Trichoptera being dominated by Diptera especially the larval midges of Chironomidae associated with annelid worms of Tubificidae. Other insect larvae of the sewage-fed ecosystem belong to Ceratopogoninae, Tetanoceridae, Anthomyiodae, Tabanidae, Straitoimyidae, etc. Some of these are good fish food organisms, but the predacious type Hemiptera (Notonentcidae, Belostomatidae, Nepidae, etc.) Coleoptera (Ditiscidae, Hydrophilidae, Curculonidae, etc.) and a few Odonata-Zygoptera are needed to be controlled. An emulsion of soap and vegetable oil (like, mustard or linseed) @ 4 kg/ha and in the ratio of 1 : 3 is usually applied to control these insects.

10. FISH DISEASE

Various kinds of fish disease are encountered in the sewage-fed pond. Among these, the common diseases are tabulated in Table - 1.

11. HARVESTING PATTERN

Taking advantage of high productivity and carrying capacity, the sewage-fed ponds are usually stocked at a higher density compared to that in ordinary freshwater pond. After 5-6 months' culture when the biomass grows to an optimal level, the stocking density is thinned out through periodical and partial harvesting. Fast growing species like *Catla catla*, *Hypohthalmichthys molitrix*, *Cyprinus carpio*, etc. are removed on attaining around 1 kg while *Cirrihinus mrigala* and *Labeo rohita* become harvestable at 500 g. Water depth of the pond is reduced by dewatering for final harvest when the fishes are removed by repeated drag netting.

Table 1 : Commom diseases of fishes in sewage-fed ponds

Sl. No.	*Disease*	*Name of host*	*Causative organism*	*Incidence*	*Symptoms of disease*	*Clinical signs*	*Predisposing factors*	*Remedial measures*
1.	Dropsy	Indian major carps.	*Aeromonas* sp.	Summer months	Accumulation of water in body cavity or scale pockets.	Dysfunction of kidney.	High organic load at pond bottom.	Maintenance of pond sanitation 100. mg of terramycin or sulphadiazine per kg of fish feed to be supplemented at the tune of 3% of the body weight.
2.	Tail & fin rot	—do—	—do—	—do—	Whitish margin in fins.	Putrifaction of fins		—do—
3.	Myxosporidiasis.	—do—	*Myxobolus* sp. *Thelohanellus* sp. *Chloromyxum* sp.	Winter months	White cysts on gills and body, reduced appetite and weakness.	Excessive secretion of mucus, perforation of scales, clubbed gill filaments.	Overstocking presence of sporcs in the ecosystem.	Maintenance of pond sanitation, thinning of pupolation. Provision of yeast in feed.
4.	Trichodinosis	—do—	*Trichodina* sp.	Post monsoon & winter months.	Frayed fins, excessive secretion of mucus.	Pale gill, worn out gill filaments.	Higher organic load at pond bottom, chronic exposure to low D.O, low apetite in winter.	Maintenance of pond sanitation. Dip treatment in 2-3% NaCl for 3-5 minutes.
5.	Dactylogyrosis & Gyrodactylosis.	—do—	*Dactylogyrus* spp. *Gyrodactylus* sp.	—do—	Fading of colour dropping & folding of fins, surfacing & splashing.	Excessive scretion of mucus, damage of gill epithelium.	—do—	—do—
6.	Argulosis	—do—	*Argulus* sp.	Summer & pre-monsoon months.	Rubbing body against pond dykes, splashing.	Excitation, extra pigmentation.	Higher organic load at pond bottom.	Dip treatment in 2-3% NaCl for 3-5 minutes. pond sanitation.

12. YIELD RATES

On the basis of experimental cultures taken up for a decade at the Rahara Research Centre of the CIFRI, the estimates of production from the sewage-fed ponds have been made for mixed culture of carps. In carp culture, stocking density for the surface feeders was increased from 30 to 40% by reducing column feeder from 25 to 20% and bottom feeder from 45 to 40%, but no appreciable change in the yield rate was noticed, suggesting thereby that the sewage-fed ponds are equally good for surface feeders and bottom feeders.

12.1 Yield of carps

In mixed culture of five carp species in sewage-fed pond, the yield rate usually varies from 5.4 to 8.6 t/ha/yr, the average production from such an ecosystem being 7 t/ha/yr. During the first half of the year the production comes to about 3000 kg/ha. Generally, the fishes grow around 500 g to 1 kg during culture operation.

Results of some experimental trials undertaken at Rahara Research 'Centre of the CIFRI are given in Table - 2.

Fig. 3. *A haul of carps from a sewage-fed pond at Rahara fish farm.*

Fig. 4. *A haul of giant freshwater prawn raised in a pond fertilized with sewage.*

Table-2 : Results of carp production trials in same experimental sewage-fed ponds at Rahara farm of CIFRI.

Expt. No.	*Year of expt.*	*Sewage fertilization during culture* X105 1/ha	*Sewage water ratio*	*Species stocked*	*stocking density per ha*	*Production kg/ha*	*Projected yield* kg/ha/yr
I	1975-76	84.4	1 : 1	C.R.M.Sc.Cc	24,000	5,452/9M	8,603
II	1976-77	231.9	1 : 2	- do -	15,000	7,200/yr	7,200
III	1977-78	87.7	1 : 2	- do -	10,000	5,402/yr	5,402
IV	1979-80	55.6	1 : 2	- do -	15,000	3'070/6M	6,140
V	1980-81	185.0	1 : 2	- do -	18,000	6,688/10M	7,826
VI	1981-82	150.5	1 : 2	- do -	18,000	4,658/7M	7,984
VII	1982-83	270.0	1 : 1	- do -	18,000	8,619/yr	8,619

13. ECONOMICS

In sewage-fed fish culture expenditures on supplentary feeding and fertilization with urea, superphosphate, etc. have been eliminated completely. The economics on infrastructure provided for a 8 ha farm with 5 ha water area has been calculated to examine financial viability of such fish culture technology.

I. Unit cost of establishment for a 8 ha pilot sewage-fed fish farm with 5 ha water area

Items for fixed capital cost	*Initial cost*	*Economic life*	*Depreciation/yr.*
1. Cost of Land (8 ha)	Rs. 3,20,000	—	—
2. Cost of earthwork for 5 ha water area & dykes.	,, 2,00,000	—	—
3. **Structural cost :—**			
(a) Pipelines, sewage distribution system & water drainage.	,, 1,00,000	25 years	Rs. 4,000
(b) Tubewell with pump, etc. for freshwater supply.	,, 80,000	20 years	,, 4,000
(c) Watchman's residential quarters (shade type)-2 Nos.	,, 50,000	25 years	,, 2,000
(d) Fish breeding hatchery shade with equipments.	,, 50,000	25 years	,, 2,000
(e) Lab / Office / Stores shade with fittings.	,, 1,00,000	25 years	,, 4,000
(f) Farm fencing	,, 1,00,000	10 years	,, 10,000
(g) Farm electrification with halogen lamps.	,, 40,000	25 years	,, 1,600
4. **Farm inventry :—**			
(a) Generator	Rs. 35,000	17½ years	Rs. 2,000
(b) Telephone	,, 5,000	—	—

(c) Diesel pump set with suction pipe, foot valve & delivery pipe.	,,	10,000	20 years	,,	500
(d) Sewage distribution pumps —2 Nos.	,,	25,000	20 years	,,	1,250
(e) Nets, fishing materials, farm implements, hapas, etc.	,,	20,000	10 years	,,	2,000
5. Cost of fish seed & some brooders to initiate the working of the farm.	,,	15,000	—		—
	Rs.	11,50,000		Rs.	33,350

II. Recurring expenditure to operate a 8 ha fish farm with 5 ha water area for one year :—

Items of working capital i. e. , variable cost	*Amount*	*Total expenditure/yr*
1. **Factor service :—**		
(a) Tax for land & structures	Rs. 500	
(b) Wages for 4 regular Watchman per year.	Rs. 36,000	
(c) Wages for 6 casual Fisherman for 4 months per year.	Rs. 10,800	
(d) Wage for a Farm Manager on regular basis per year.	Rs. 16,500	
(e) Pond preparation, weed clearance, etc.	Rs. 2,500	
(f) Cost of diesel, electricity, etc.	Rs. 7,000	
(g) General maintenance	Rs. 15,000	
	Rs. 88,300	Rs. 88,300

2. **Material input (towards) :—**

(a) Spawn production :

(i) Cost of pituitary glands (4,000 mg) @ Rs. 2/mg.	Rs. 8,000	
(ii) Cost of distrilled water, saline, glycerol, etc.	Rs. 100	
	Rs. 8,1000	Rs. 8,1000

(b) Fry production :

(i) Cost of lime (500 kg) @ Re 1/kg	Rs. 500	
(ii) Pest control & management	Rs. 1,000	
(iii) Supplementary feed (500 kg) @ Rs. 1.50/kg.	Rs. 750	
	Rs. 2,250	Rs. 2,250

(c) Fingerling production :

(i) Cost of lime (120 kg) @ Re. 1/kg	Rs. 120	
(ii) Supplementary feed (1000 kg) @ Rs. 1.50/kg.	Rs. 1,500	
	Rs. 1,620	Rs. 1,620

(d) Table-size fish & prawn production :

(i) Cost of lime (1,500 kg) @ Re. 1/kg.	Rs. 1,500	
(ii) Cost of prawn (*M. rosenbergii*) juvenile (5,000 nos. for stocking @ 1,000/ha) @ 25 paise each.	Rs. 1,250	
	Rs. 2,750	Rs. 2,750

(e) Brooder raising :

(i) Supplementary feed (1,500 kg) @ Rs. 1.50/kg.	Rs. 2,250	
(ii) Pond sanitation & fish health care.	Rs. 250	
	Rs. 2,500	Rs. 2,500

(f) Farm Office/Lab. :

(i) Stationary	Rs. 500	
(ii) Chemicals, disinfectants, soaps, etc.	Rs. 1,500	
	Rs. 2,000	Rs. 2,000
Total recurring costs	Rs. 1,07,520	Rs. 19,220

N.B.—Brooders for spawn, spawn for fry, fry for fingerlings, fingerlings for table-size fish and adult fishes for brooder productions will be provided from the farm produces.

III. Annual investment :—

1. Depreciation on fixed capital cost per year	Rs. 33,350
2. Interest on fixed capital cost @ 12% per year	Rs. 1,38,000
3. Recurring costs (working capital) per year	Rs. 1,07,520
4. Annual interest on working capital @ 15%	Rs. 16,128
	Rs. 2,94,998

IV. Expected annual return :—

Sale proceeds of farm produce	*Quantity*	*Rate*	*Amount*
1. Spawn (surplus after farm need)	86 lakhs	Rs. 250/lakh	Rs. 21,500
2. Fry (surplus after farm need)	23 lakhs	Rs. 3000/lakh	Rs. 69,000

3.	Fingerlings (-do-)	30 thousand	Rs. 225/thousand	Rs. 6,750
4.	Table-size Fish	35,250 kg.	Rs. 12/kg.	Rs. 4,23,000
5.	Prawn (100 g size)	282 kg	Rs. 60/kg	Rs. 16,920
				Rs. 5,37,170

Annual Investment	*Annual Turnover*	*Annual Profit*	*Fixed Capital Cost*	*Return over Investment*	*Profit to Turnover*	*Return over Fixed Capital Cost*
2,94,998	5,37,170	2,42,172	11,50,000	82.09 %	45.08 %	21.06 %

New present value (NPV) or Net present worth (NPW) for benefit.	Rs. 11,55,543 for Rs. 21,79,548
Pay off period (for Fxed Capital)	10 years
Internal rate of return (IRR)	30.37%

14. CONSTRAINTS

Like any other package of practices, the sewage-fed fish farming suffers from constraints related to environmental, legal, financial and social factors.

14.1 **Environmental contstraints**

Sewage water utilization in agriculture and aquaculture has certain inherent draw-back. They are more pronounced where raw sewage is directly utilised by the fish farmers for raising carps. Such practices may cause fish mortality due to following reasons :

(a) Sudden increase in organic load of the pond and subsequent depletion of dissolved oxygen.

(b) Rise in atmospheric temperature causing increased rate of bilogical degradation of the putricible organic material and subsequent depletion of dissolved oxygen.

(c) Lowering photosynthetic activity through prolonged cluody day causing depletion of dissolved oxygen.

(d) Development of high concentration of NH_3 and H_2S at the pond bottom due to accumulation of organic debris (sludge) endangering fish life.

(e) Parasitic infection in fish stock causing various deseases like, tail and fin rot, worm diseases, argulosis, etc. (Table-1)

In addition to the above, aquaculture system utilising sewage water have potential microbiological problems associated with the health of the fish, the transmission of human pathogens and maintenance of the quality of aquaculture effluents discharged. Human waste contain large number of pathogens capable of transmitting diseases such as cholera, typhoid, dysentery, jaundice, etc. The sewage treatment method are designed not only to remove the putricible organic matter but also to reduce the pathogen load. It is therefore, recommended to utilise only treated waste water for aquaculture. Experiments have shown that waste stabilization method of sewage purification reduces bacterial load, specially *Salmonella*, coliforms and faecal-Streptococci to a considerable extent probably due to antibacterial properties of algae and high pH value of stabilization pond.

Further constraints of the system is the bio-accumulation of heavy metal in fish flesh since mixed sewage is likely to contain some metallic ions. Such accumulation is likely to be transmitted to human being through consumption of fish reared in such an ecosystem. Detergents which are commonly used for domestic purposes find their way into sewage and cause problem. Some of the components of detergent like, livo-alkyl benzene sulphonate (ABS) are toxic to fish life and some like sodium triple phosphate cause phosphate pollution resulting in high algal bloom. During the course of treatment nearly 50% of ABS are removed. Recent investigations have proved that water hyacinth possesses properties of absorbing heavy metallic and other toxic industrial wastes including phenol from waste waters.

14.2 **Legal constraints**

States in eastern region abound in natural endowments, human skills, and conventional wisdon in respect of culture fisheries ; but adequate legislative support was often lacking fot the development of inland fisheries. The ownership/control of water areas belonging to Government in several States are vested with the departments other than fisheries. Further, community ownership through agency of Panchayates or local self bodies did not aid development of fisheries mainly due to multiple uses of water. In respect of private waters, structural rigidities namely multiple ownership, public easement right inpede the development process. The leasing arrangements have generally been devoid of development bias mainly because of the short term lease period. Vast majority of water bodies particularly in eastern India, are privately owned where leasing arrangements are a bipartiate affairs depending on market forces. There is an imperative need for farming tenancy legislation similar to agricultural lands.

14.3 **Financial constraints**

Institutional financing arrangements need to be streamlined with a view to reconciling them with equity objectives.. In order to meet the increased capital requirements of new technology, selective, liberalised lending procedure is very essential. In case of ownership tanks, and primary treatment facilities for sewage, banks should accept water bodies as adequate security contrary to existing procedure.

14.4 **Social constraints**

Illegal removal of fish crop has been a long practised disincentive. Existing provision in the law of land can be made more stringent. Apparant repulsion by a section of the community to accept the sewage-fed pond grown fish due to fear of any contamination or for prejudices need to be removed by convincing them about the hygienic garantee.