8th WEDC Conference: Water and waste engineering in Asia: MADRAS: 1982

STUDIES ON THE PRODUCTIVITY OF AIR BREATHERS AND CROP PRODUCTION IN WASTE WATER

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INTRODUCTION

Recycling and reuse of nutrients and other valuable materials in domestic and industrial wastes is one of the effective methods for utilising the waste waters. Use of sewage for aquaculture followed by agriculture could be adopted in several regions of the developing world. Consideration is to be given not only to cost but also to health and environmental factors. Utilisation of waste waters through reuse and recycling is increasing in importance, since waste water is a resource rather than waste, as it contains appreciable amount of nitrogen, phosphorus and potash.

The stabilisation pond which functions utilising solar energy and bacterial algal symbiosis is an effective low cost system. Effluent from the stabilisation pond contains nutrients, phytoplankton, zooplankton and bottom fauna which are ideal fish food. An integrated and environmentally compatible system can be practised for fish culture and the effluent can be used for cultivation of short-term, long-term, ornamental, commercial and fodder crops.

Data on pilot plant studies with stabilisation pond followed by fish pond with effluent utilisation for cultivation of ornamental and other crops are discussed briefly.

MATERIAL & METHODS

An integrated system of stabilisation pond and fish ponds are located at Nagpur 21°N in Central India. The stabilisation pond has a dimension of 30.5 m x 24.4 m x 1.2 m followed by 6 fish ponds of 5.5 m x 16.5 m x 1 m depth each. Domestic sewage from NEERI campus as well as city sewage is being treated in the stabilisation pond at an organic loading rate of 150 Kg/hect/day. A fish pond receiving only fresh water was operated as a control. Fish ponds II & III directly receive effluents from stabilisation pond is parallel, whereas ponds IV, V & VI are in series. Monoculture with air breathers such as Clarias and Heteropneustes with a loading of 20,000/hect were adopted. The series ponds IV & VI were stocked with Heteropneustes and V with Clarias.

Combined effluents from all the fish ponds are discharged into a sump from where it is utilised for cultivation. A field layout consisting of 24 plots of $9m^2$ with a net plot size of $4m^2$ are used for cultivation of regular crops and plot size of $6m^2$ for Jasminum (ornamental flowers) crop. The plots were prepared under randomised block design. Wheat and Jasmine were grown using the fish pond effluent as an irrigant.

Samples from the stabilisation pond, fish ponds and combined effluent were subjected to physico-chemical analysis, such as temperature, pH, DO, BOD, different forms of nitrogen and phosphate as per the Standard Method '(Ref.1)'. Samples for dissolved oxygen were collected from surface and bottom. Biological samples include phytoplankton, zooplankton and bottom fauna. Diurnal variation, primary productivity measurement, protozoa and helminthic cyst and fish biometry formed part of the observation. Microbiological analyses consisted of Salmonella sp. total and faecal coliforms.

OBSERVATIONS & CONCLUSIONS

(i) Fish ponds in parallel (II & III) : The BOD of raw sewage ranged from 110 to 510 mg/l, with about reduction of 65% in the stabilisation pond with a detention time of 4 days and the effluent BOD was in the range of 58 to 165 mg/l. In ponds II & III, a further BOD reduction took place with a detention time of 1 day. The effluent BOD was in the range of 35 to 112 mg/l. In both the ponds, except on very few occasions, surface and bottom showed critical levels of dissolved oxygen specially during the predawn hours. However, on some occasions DO at the surface rose upto 4 mg/l but less than 2 mg/l at the bottom. Dissolved oxygen reached critical levels on several occasions.

Zooplankton mainly comprised of Protozoa, Rotifera and Cladocera in the range 200 to 17,000/l of Rotifera and 250 to 28, 250 Cladocera/l respectively. Benthic fauna was mostly represented by Chironomus larvae in the range of 2 to 10,000 per Eckman Dredge.

Tubificidie were recorded occasionally in the pond system indicating that the bottom of the fish ponds did not tend to become septic which is a pertinent observation in fish culture.

In all 36 different genera of algae were observed in the pond system representing green and blue-green algae. Among the blue-greens, the dominant forms were Spirulina and Microcystis. The presence of algal blooms was found useful for the pond eco-system in view of oxygen donation through photosynthetic activity. The blooms did not give any harmful effects nor fish kills due to oxygen depletion. The succession of the different algal forms did not follow a regular trend. In the tertiary system, Spirulina Sp., was dominant which contains 70% of the protein. Moreover, these algal populations serve as food for the herbivorous fish such as Cyprinus carpio which were successfully cultured in these ponds on earlier occasions.

Microbiological studies indicate that the raw sewage had Salmonella Sp., in the range of 16 to 385/100 ml. Effluents from the stabilisation pond is in the range of 3 to 82/100 ml with a reduction of 55.2 to 93.7%. Ponds II & III had a Salmonella count of 1 to 23/100 ml, with a reduction of 89 to 99%. The coliforms in the raw sewage were in the range of 8.3×10^6 to 8.9×10^7 per 100 ml. The percent coliform reduction in the stabilisation pond ranged from 58 to 99.2% and in fish ponds 90 to 99.95%. The faecal coliforms in raw sewage ranged from 5.5×10^6 to 5.7×10^7 with a reduction of 93 - 99.9%.

Helminthic cyst and protozoa were found in raw sewage in large numbers, but could not be detected in the effluents of the stabilisation pond and fish ponds indicating a 100% removal in the pond system. It provides additional evidence that it is safer to use treated effluents for agriculture rather than raw sewage.

(ii) Fish ponds in series (IV, V & VI) : BOD of the effluent is in the range of 28 to 127 mg/l with a detention time of 1 day in each of the ponds. DO on most of the occasions during pre-dawn hours was about 4 mg/l at the surface and 2 mg/l at the bottom. The DO collected during pre-dawn, mid-day and post sunset indicated that the tertiary pond system (IV) do not deplete dissolved oxygen to critical levels especially at the bottom at pre-dawn hours. It would thus be advantageous to culture carp (poly-culture) in this pond system. Zooplankton mainly represented by Rotifers and Cladocera were in the range of 200 to 22,500 and 250 to 15,250/l respectively. The bottom mostly comprised of Chironomus larvae in the range of 2 to 10,000 per Eckman Dredge. The effluents from these fish ponds had Salmonella in the range of 0 to 21/100 ml. Most of the times one litre of the sample was found to be devoid of Salmonella. Coliforms and faecal coliforms showed reduction of 97 to 99.99% and 99.5 to 99.99% respectively. Ponds in series gave better removal of Salmonella and coliforms and faecal coliforms rather than ponds directly receiving stabilisation pond effluents.

Heteropneustes stocked in pond IV & VI attained a maximum growth of 151 gms and 147.5 gms at the end of one year. The Clarias stocked in pond VI attained a maximum weight of 374 gms. Of the 2 varieties of fish, Clarias had a better growth. The control pond indicated a growth of 75 gms at the end of one year. The air breathers in general do not depend upon the dissolved oxygen in water and can tolerate adverse environmental conditions such as low levels of dissolved oxygen and septic decay. Moreover, the ponds have rich bottom fauna and also forage fish like Lebistes. Fishes during trial netting did not show any visible signs of injury or malformation. They were swift in their activities.

CROP PRODUCTION

Studies on the effect of irrigation with the fish pond effluent have shown that the nutrients available through irrigation with fish pond effluent (without additional fertilizer) were adequate to maintain the growth and yield level of wheat crop on par with that resulting from the standard practice (well water irrigation + recommended dose of NPK through fertilizers). Application of fertilizers to the fish pond effluent irrigated wheat crop to the extent of 100% supplemental dose (recommended dose - NPK contributed by the F.P. effluent) resulted in an appreciable but satistically insignificant increase in the yield of the crop (about 22%). Application of half supplemental dose did not result in any appreciable increase.

Effect on soil properties indicated that fish pond effluent irrigation tend to increase the soluble salts, total nitrogen, organic carbon, nitrate and available phosphate content of soil in relation to the respective base values (in the beginning of the experiment) but there were no significant differences in comparison with the control. There was, however, no apparent change in the exchangeable cations, Cation Exchange Capacity and Exchangeable Sodium Percentage of the soil.

The data on uptake of major plant nutrients by wheat have shown that there was significant to highly significant increase in the uptake of nitrogen, phosphorus and potash as a result of irrigation with fish pond effluent in comparison with the control (Standard practice). Application of supplemental NPK to the fish pond effluent irrigated crop tend to further increase the uptake of NPK. As a result, the N, P and K content of the wheat grain as well as the straw also increased in comparison with the control, indicating the enhanced nutritional quality of the wheat grain as well as the straw.

The data also revealed that the level of combined nutrient utilisation efficiency (Kg of grain produced per Kg of nutrients NPK) under irrigation with fish pond effluent was relatively better than that under standard practice while the specific nutrient utilisation efficiency in respect of nitrogen was poor. There was a considerable improvement in the combined (NPK) as well as a specific (nitrogen) nutrient utilisation efficiency due to application of supplemental dose of NPK (100 percent) in comparison with the standard practice as well as the unfertilized fish pond effluent irrigation.

Economic evaluation of the treatments have shown that the net profit available from utilisation of fish pond effluent for production of wheat crop was 50% higher than that under standard practice (control) while it increased further when supplemental dose of NPK (100 percent) was applied. This increase was about 11 percent over the unfertilized irrigation with fish pond effluent and 67 percent over the standard practice.

This indicates the potential benefit of the recycling of renovated waste water in the development of agriculture as well as the prevention of environmental pollution.

In another set of field experiment, ornamental flowering crop of Jasmine (Mogra) is also under observation which show promising trend.

REFERENCES

American Public Health Association; American Water Works Association; Water Pollution Control Federation — Standard Methods for the Examination of Water & Waste Water, 14th Edition, 1975 (a book).