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Responses of some bio-geochemical cycling bacteria and their activities to management protocols under polyculture with Indian major carps and freshwater giant prawn

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Abstract

Estimations of the population size of some biogeochemical cycling bacteria and their activities were made in outdoor tanks (4500 l) in triplicate used for four treatments: monoculture of freshwater giant prawn, mixed culture of Indian major carps (catla and rohu) and polyculture of Indian major carps and freshwater giant prawn and a reference control with application of feed alone during the grow out period of 125 days, while maintaining the same initial manural dose and supplementary diet for all the treatments. Enumeration of different groups of bacteria at regular intervals from water and sediment samples of these tanks revealed that mean counts of heterotrophic bacteria — HB (water — 11.81×10^3 ml^{-1}, sediment — 33.8×10^5 g^{-1}), ammonifying bacteria — AB (water — 9.65×10^3 ml^{-1}, sediment — 28.8×10^5 g^{-1}), protein mineralizing bacteria — PMB (water — 1.86×10^3 ml^{-1}, sediment — 18.45×10^5 g^{-1}) and nitrifying bacteria — NB (water — 33.66×10^3 ml^{-1}, sediment — 13.62×10^4 g^{-1}) were distinctly reduced (ANOVA, $P<0.001$) in the carp–prawn polyculture compared to prawn monoculture or mixed carp culture. On the contrary, there was significant rise (ANOVA; $P<0.001$) in the counts of aerobic cellulose decomposing bacteria — CDB_A (water — 3.93×10^3 ml^{-1}, sediment — 17.06×10^5 g^{-1}), anaerobic cellulose decomposing bacteria — CDB_{An} (water — 1.50×10^3 ml^{-1}, sediment — 44.26×10^5 g^{-1}) and *Vibrio* sp. (water — 11.21×10^3 ml^{-1}, sediment — 39.21×10^5 g^{-1}) in the mixed carp culture than the rest. Reduction in the counts of bacteria in the carp–prawn polyculture implied a better utilization of feedlot resulting in less accumulation of feed remnants by the compatible and symbiotic association of fish and prawn. As a consequence, a clearly more balanced ecosystem and benign environment with reduced level of feedlot-dependent pollutants has been developed. It becomes apparent that main differences among the culture systems were the function of organic matter utilization which was zero in the control, and maximal in the polyculture and the resulting organic substrates accumulation in the water. In the carp–prawn polyculture, there was significant reduction in the counts of those groups of biogeochemical cycling bacteria (AB, PMB, NB, CDB_{An}, *Vibrio* sp.) which mostly belong to the Gram-negative group. This indicates the possibility of exploiting carp–prawn polyculture as an associative system for reducing the Gram-negative water borne enteropathogenic bacteria that causes epidemiological problems.

Keywords: Biogeochemical cycling bacteria; Management protocol; Prawn monoculture; Carp culture; Polyculture; Freshwater prawn

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1. Introduction

The concept of composite fish farming has been developed on the idea of culturing fishes together or in association for achieving a balanced fish population within the culture unit. Because of the balanced fish population and their full utilization of food resources, the polyculture system of fish farming has been popularized worldwide. In practice, it consists of raising compatible species that occupy different ecological niches and feed on different food resources in the farm at optimal level for maximum fish production (Jana and Jana, 2003). It develops a symbiotic relationship among the species and thereby creates an ecologically benign environment and, consequently, minimizes aquaculture-dependent environmental degradation. As a result, polyculture with omnivorous or herbivorous filter feeding fish has been booming in the world aquaculture with as high as 90% contribution from Asia (Azim et al., 2004a,b,c).

Several studies have reported the impact of management protocols of aquaculture on the abundance of bacteria occurring in water and sediments (Jana and Roy, 1985; Ganguli et al., 1999; Jana et al., 2001a). The microbial changes occurring in the sediment water interface, primary production and the organic carbon balance have been investigated by Avnimelech and Lachar (1979), Rappoport and Sarig (1979) and Zur (1981) in the experimental fish culture unit and in intensively fed fish ponds in Israel. It is stated that inhibition of fish growth usually occurs between 50 and 70 days after stocking (Rappoport and Sarig, 1979; Raveh et al., 1979) in intensively fed and aerated fish ponds, which was attributable to the accumulation of decay products and their degradation leading to anaerobic conditions in the pond sediment. Avnimelech et al. (1981) demonstrated that carp do not actively feed on bottom debris once anaerobic conditions become established in the pond sediment. The complete disappearance of macrozoobenthos upon the development of anaerobiosis in the sediment has also been observed (Zur, 1980). Ram et al. (1981) showed that an exponential increase in all the groups of bacteria with the exception of nitrifying bacteria, was observed in the first ten days and approached a steady state. In an intensively stocked and fed fish pond, all the different groups of bacteria displayed a rapid change in numbers during the first 2–8 days following fish stocking, and a subsequent approach toward a steady state (Ram et al., 1982).

Considerable information on the production of both Indian major carps and exotic carps under polyculture are available (Jhingran, 1995; Jana and Webster, 2003). As the polyculture with Indian and exotic carps is becoming less profitable due to low price of the carp species, the farmers tend to search for more suitable candidates, with high market price and demand for polyculture. As a consequence, polyculture with freshwater prawns and Indian major carps together has become a more profit making culture practice in India. Realizing the potential of the freshwater giant prawn in aquaculture, considerable efforts have been invested in many countries for culturing this species in an intensive system under various commercial conditions (Michael, 1982; Cohen et al., 1988). Being benthophagic, freshwater giant prawn, *Macrobrachium rosenbergii*, is a good candidate species for polyculture with surface and column feeding carps (Mukhopadhyay et al., 2003). Das et al. (1991) have stated that stocking of juvenile freshwater prawn together with rohu, common carp, and Java carp in pen culture in deep water rice fields resulted in increase in rice production.

However, specific information about the polyculture of Indian carps and freshwater giant prawns on the abundance of different nutritional groups of bacteria is hardly available. As the carps and freshwater giant prawns are phylogenetically entirely different phyla with different feeding modes, the carp–prawn association is expected to exploit greater utilization of food niches in the pond ecosystem and maintain the benign eco health of the culture unit as a result of associative symbiosis or protocooperation. The purpose of the present study was to investigate the qualitative changes in some biogeochemical cycling bacteria that may occur in water and sediment of the culture unit and also to examine the associated changes in the water quality attributable to the polyculture of giant prawn and carps.

2. Materials and methods

The present study used twelve experimental tanks (4500 l, 3 m × 1.5 m × 1.2 m) located in the campus of University of Kalyani, Kalyani. All the tanks were thoroughly cleaned, dried, and provided with 15 cm dry alluvial soil collected from neighbouring agricultural land. The tanks were filled with dechlorinated ground water (pH 7.2 – 7.4) two weeks prior to application of basal manure dose. Poultry droppings, cow dung, urea and single super phosphate were mixed in different proportions to create a fixed CNP ratio of 88.6: 7.5: 1 according to the methods described by Jana et al. (2001b) and were applied at the rate of 2000 kg ha^{-1} as the basal dose for developing the necessary plankton bloom.