

Phosphate Fractions in Sediments of Aquaculture Systems of Cochin

P. Muhamed Ashraf, Leela Edwin, A.G. Gopalakrishna Pillai and K. Ravindran

*Central Institute of Fisheries Technology
P.O. Matsyapuri, Cochin - 682029, India*

This study aims to present quantitative information on various phosphate fractions in the aquaculture farms located in and around Cochin. The results of the analysis of soil samples have shown that loosely bound P was negligible (0.0-0.02 ppm) in all the samples. Concentrations of other fractions viz., Al bound P, Fe bound P, Ca bound P, inorganic P and total P were in the range of 1-68 ppm, 16-159 ppm, 38-428 ppm, 339-633 ppm and 363-705 ppm, respectively. The P concentration in water samples ranged from 0 to 0.325 ppm.

Key words: Bound phosphorus, Aquaculture farms, Cochin

Primary production in lakes and ponds depends on the availability of light, phosphorus and nitrogen. Phosphorus in the form of organic phosphates tends to be the element controlling the rate of phytoplankton growth and biomass formation (OECD, 1982). Phosphorus availability in submerged soil depends on reduction of ferric compounds, organic transformations influencing P release, release of phosphate ions from the exchange between organic anions and phosphate ions in Fe-P and Al-P compounds and increased P diffusion under submerged conditions (Sanyal & Dutta, 1991). Nitrogen and phosphorus are also implicated in eutrophication. The chemistry of transformation of P in aquaculture pond sediments has received scant attention. This study aims to present quantitative information on various phosphate fractions in the sediments of aquaculture farms of Cochin.

Materials and Methods

Soil and water samples were collected from six aquaculture farms (Stations 1-6) located in and around Cochin, Kerala (India). The sediment samples were air-dried and lumps were crushed by a wooden hammer. A sequential phosphate fractionation scheme (Shrestha & Lin, 1996) was followed for the estimation of sediment bound phosphates.

Ammonium chloride, ammonium fluoride, sodium hydroxide and hydrochloric acid (modified as per Hosomi *et al.*, 1982) were used to fractionate loosely bound P, Al bound P (Al-P), Fe bound P (Fe-P), and Ca bound P (Ca-P), respectively. Total P was determined by igniting the sediment at 550°C and extracting inorganic P with 1N H₂SO₄ (Shrestha & Lin, 1996). The P in the extract and water samples was estimated by ascorbic acid method (APHA 1990). The pH and organic carbon were determined as per standard procedures (Jackson, 1973).

Results and Discussion

The results indicated that the inorganic phosphorus, comprising of loosely bound P, Al-P, Fe-P and Ca-P, varied from 339-633 ppm (Table 1). Station 5 recorded the highest concentration (633 ppm) and station 1, the lowest (339 ppm). Inorganic phosphorus accumulate in the sediments through sedimentary P adsorption. Increased P buffer capacity is attributed to P adsorption from soil solution by the reprecipitated poorly crystalline ferrous hydroxides or ferrous carbonates formed by soil reduction. (Tian-ren *et al.*, 1989).

The Ca-P fraction varied from 38 to 428 ppm and the maximum and minimum levels

Table 1. Concentrations of phosphate fractions (ppm), organic carbon (%) and pH in sediments and water

Station No.	Loosely bound P	Al bound P	Fe bound P	Ca bound P	Inorganic P	Organic P	Total P	Water P	Organic Carbon %	pH
1	0	0	16	38	339	146	485	0	8.26	6.33
2	0.02	31	67	234	425	31	456	0	2.10	9.05
3	0	31	45	176	355	8	363	0.27	0.85	8.20
4	0	67	127	428	633	72	705	0.35	3.28	8.39
5	0	69	127	317	517	34	551	0.14	1.43	7.70
6	0	63	159	340	492	107	599	0.06	9.31	7.91

were recorded from stations 5 and 1, respectively. The pH recorded for soil samples from station 1 was 6.33 and Ca-P was very low in this sample. The correlation data reveal that there was a marginal positive correlation (0.5834) between pH and Ca-P. According to Ponnampereuma *et al.* (1967), accumulation of CO₂ would tend to bring down the pH, under anaerobic conditions. This will also cause an increase in HCO₃ concentration in the solution phase through the solvent action of CO₂ on carbonates and would also cause desorption of several exchangeable cations (e.g. Fe²⁺, Ca²⁺, Mg²⁺, NH₄⁺) to maintain the electroneutrality in solution. Samples of soil from other stations had higher Ca-P concentrations (176-428 ppm) and all these were alkaline (pH, 7.7-9.0). According to Golterman (1988), the distribution of phosphate over the Ca and Fe bound pools depends on pH, phosphate concentration and the concentration of Fe(OOH) in the sediments.

Concentration Fe-P fraction varied from 16 to 159 ppm and the highest level was in station 6 and the lowest, in station 1. Results showed that roughly, the concentration Fe-P was twice that of Al-P except in the case of station 1 and station 3. According to Willet (1989) ferric oxide reduction may be the dominant source of P released during flooding. The role played by Al-P or Ca-P is usually secondary (Sah & Mikkelsen 1986). However the amount of P released was strongly inhibited by resorption. Al bound P was absent in station 1 and in other cases

it varied from 31 to 69 ppm. Station 2 and station 3 recorded 31 ppm each and in the other three stations, the range was 63-68 ppm. Flooding of soil is known to increase the soluble P concentrations which reaches a maximum and subsequently falls probably due to readsorption of P on clays and aluminium hydroxides, precipitation or microbial degradation of organic anion at the exchange site, causing P resorption from soil solution (Ponnampereuma, 1985; Tian-ren *et al.*, 1985).

Loosely bound P fraction was negligible or absent in all soils. This fraction is the easily exchangeable form of P and adsorption requires large surface area (Maine *et al.* 1992). Soil samples from station 1 and station 6 recorded higher levels of organic P (146 and 107 ppm) and in all other cases it was between 8 and 72 ppm. The organic carbon content in station 1 (8.36%) and station 6 (9.31%) were very high compared to other stations. The major forms of organic phosphate accumulation are as inositol phosphates comprising of inositol hexakis and pentakisphosphates (up to 60%), nucleic acids and phospholipids (Anderson, 1980). It is also noted that mineralisation of organic P has been considered as a minor source of P in flooded soils (Uwasawa *et al.*, 1988a) except in flooded organic soils (Uwasawa *et al.*, 1988b).

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