PHOSPHORUS: NUTRIENT ELEMENT FOR CROP PRODUCTION AND ENVIRONMENTAL QUALITY

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Phosphorus is one of the key elements necessary for the growth of all forms of life including plants, animals and micro-organisms. There is no substitute for phosphorus in food production and it cannot be manufactured, hence its greater significance to humanity. Limited phosphorus reserves exist only at the earth's crust in the form of phosphate rock. The natural phosphorus flow occurs very slowly (can take place over 1 million years), remains relatively constant in quantity, and contributes to a stable closed loop. The situation has however been significantly changed by human activities, particularly since industrialization, which has resulted in some serious environmental problems that modern societies face today.

Phosphate rock is initially converted to phosphoric acid by reaction with sulphuric acid. The phosphoric acid is further processed to produce fertilizers, food-grade and feed-grade additives, and detergents (Liu, 2008). In general, good agronomic management requires use of P to optimize crop growth, whereas the excessive application of P may degrade water quality. Thus, phosphorus plays a key role in crop production as well as environmental sustainability.

PHOSPHORUS AS A NUTRIENT FOR CROP PRODUCTION

Historically phosphorus played a great role in enhancing and sustaining crop productivity worldwide. Phosphorus is a critical element in natural and agricultural ecosystems throughout the world as its limited availability is often the main constraint for plant growth in highly weathered soils of the tropics. Soil P is a finite, non-renewable and limited resource. The total phosphorus content of most surface soils is low, averaging only 0.06% phosphorus, compared to an average soil content of 0.14% nitrogen and 0.83% potassium.

In soil, phosphorus is found in organic and inorganic forms. Organic phosphorus is found in plant residues, manures, and microbial tissues. Soils low in organic matter may contain only 3% of their total phosphorus in the organic form, but high organic matter soils may contain 50% or more in the organic form. Therefore, continuous supply of P through manures and fertilizers is indispensable for crop production sustenance.

PHOSPHORUS AS AN ELEMENT FOR ENVIRONMENTAL QUALITY

Global assessments on water quality status have identified eutrophication as one of the most ubiquitous water quality impairments in the U.S., Europe, and Australia (Heaney *et al.,* 2001; New Zealand, 1997; U. S. Geological Survey, 1999). Eutrophication is the natural aging of lakes or streams brought on by nutrient enrichment. Normally, small amounts of nitrates and phosphates occur in all aquatic ecosystems and maintain a balanced biological growth in such ecosystems. However, if those nutrient elements along with carbon and silicon are enriched in the aquatic ecosystem through human intervention that may leads to eutrophication status.

On a global basis, researchers have demonstrated a strong correlation between total phosphorus inputs and algal biomass in lakes (Anderson et al., 2002).Too much nitrogen and phosphorus in the water causes algae to grow faster than ecosystems can handle. Significant increases in algae harm water quality, food resources and habitats, and decrease oxygen that fish and other aquatic life need to survive leading to the death of large number of fishes.

The natural levels of phosphate in the aquatic ecosystems usually range between 0.005 to 0.05 mg/L. In many countries the threshold level of P is 0.03 to 0.1 mg/L above which the aquatic bodies are vulnerable for algal blooms.

SOURCES OF PHOSPHORUS TO THE AQUATIC ECOSYSTEM

The main sources of phosphate in aquatic environment are household sewage water containing residues of detergents and cleaning preparations, agricultural runoff containing fertilizers as well as industrial effluents from fertilizer, detergent and soap industries (Pradyot., 1997).

Normally, point sources refer to the discharges from industry and urban wastewater. Diffuse sources (non-point sources) include background losses, losses from agriculture, losses from scattered dwellings, and atmospheric deposition on water bodies. The rate at which phosphorus loads enter freshwater systems varies with land use, geology, morphology of the drainage basin, soil productivity, human activities, and pollution.

Figure 1 Surface runoff from the catchment area of Upper Lake, Bhopal

PHOSPHORUS FORMS AND ITS CONTENT IN UPPER LAKE, BHOPAL

Phosphorus is considered to be immobile in soil and highly mobile in plant system. The transport of P in agriculture field can occur by surface runoff and subsurface flow. It depends upon the soil type, rate of P application, source of P, amount and intensity of rainfall, and soil P status. Phosphorus enters into water bodies either as dissolved or particulate forms.

Studies conducted by ICAR-IISS, Bhopal for a period of 3 years at Upper Lake, Bhopal also indicates that the total P in the lake water collected at pre and post monsoon sample varied from 0.28 to 0.47 mg/L with a mean value of 0.39 mg/L, which is higher than limit for eutrophication (0.2 mg/L). The total dissolved P(TDP), total reactive P(TRP) and dissolved reactive P(DRP) ranges from 0.08 to 0.17, 0.05 to 0.09 and 0.008 to 0.04 mg/L with a mean value of 0.13, 0.08 and 0.03 mg/L, respectively. The mean TDP, TRP, DRP, Dissolved Organic P (DOP) and Particulate P (PP) were 31.05, 20.31, 10.39, 18.73 and 68.94% of TP, respectively. Thus, the phosphorus fractions in the water samples of upper lake, Bhopal revealed that 62.28 to 69.72% of the total P (0.37 mg/l) was in particulate form (more than 450 nm particles) and remaining 30.38 to 37.72 was in ionic and dissolved form (less than 450 nm particles) (Subba Rao et al., 2011; Kundu et al., 2015). Dissolved P originates from the release of P from soil, plants, and added fertilizer or manure. In general total P and other P fractions in post monsoon water samples were found to be higher than pre monsoon stage.

The water samples collected from different entry points (15 locations) where water enters from different sources (agricultural and municipal wastewater) to the Upper Lake (figure 2) were analyzed for various P fractions. The source of water from the city and at idol immersion location contains relatively higher TP and dissolved DRP. Among the P fractions, the bioavailable P fractions (TDP) were highest in domestic wastewater, where the dominant P fractions in the water samples from agricultural source were particulate PP.

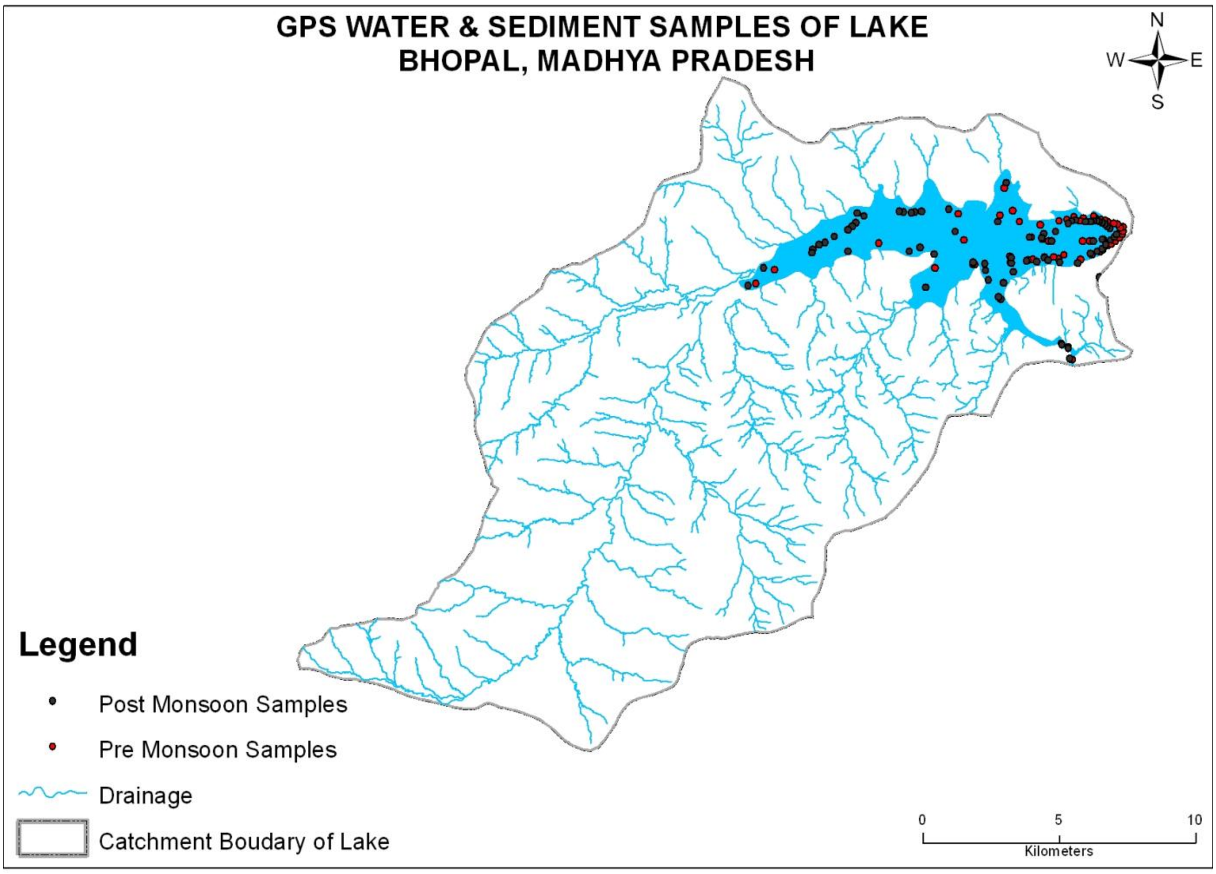

Figure 2 GPS based sampling locations from the Upper lake, Bhopal

Globally, since the late 1960s, the relative contributions of P to water bodies, both from point and diffuse sources have changed dramatically. On one hand, great strides have been made in the control of point source discharges of P, such as the reduction of P in sewage treatment plant effluent. These improvements have been due, in part, to the ease in identifying point sources. On the other hand, less attention has been directed to controlling diffuse sources of P, due mainly to the difficulty in their identification and control. Thus, control of diffuse sources of P is a major hurdle to protecting fresh surface waters from eutrophication. There are several measures available to minimize the potential for P loss in agricultural runoff, which address sources and transport of P. The overall goal of efforts to reduce P loss to water should be to balance P inputs and outputs at farm and watershed levels, while managing soil and P in ways that maintain productivity.

CONCLUSION

Phosphorus (P) is a key factor in aquatic eutrophication, and P contamination has become a common issue worldwide. Continuous application of P at higher rates to different crops may cause P pollution on one hand and escalating prices of P fertilizers in the recent past may reduce the profitability of the farmers on the other hand. Therefore, to achieve both economic and environmental safeguard it is important to develop a P management plan to utilize the available P resources efficiently in the country.

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