Introduction

Role of bottom soils in influencing the environment and productivity of various pond fish culture systems are well documented. Not only this phase helps in gradual release of different nutrients to available forms for the benefit of primary fish food organisms and, in turn, the growth of fishes but it also helps to maintain a favorable pond environment through various biochemical reactions occurring in these aquatic ecosystems (Adhikari, 2011; Boyd, 2012; Vass *et al.,* 2015). Considering the importance of bottom soils on productivity of fish ponds, Hickling (1971) designated this phase as the "Chemical laboratory of a fish pond". Basic properties of a soil group being largely different from the other ones, the fish ponds situated under a particular soil zone are likely to exhibit some specific characters of soil and water environment, which may be reflected in their biological productivity levels also. Considering this fact, Boyd *et al.* (2002), while discussing different aspects of aquaculture pond bottom soil management, suggested that the location specific soil deficiencies should be identified and treated while undertaking new fish culture programmes in any fish pond. Similar importance of soil system based pond management by taking into account the major productivity attributing soil factors for any particular soil condition has been discussed by Banerjee *et al.* (2010) and Chattopadhyay (2018).

Red and lateritic soils form an important soil group of the tropical and sub-tropical countries covering approximately 13% of the total land areas of the world. Such soils occur extensively in the South Asia, Western and Central Africa, many parts of South America, South-East Asia, Australia, India, China, Japan etc. (Sehgal, 1998). In India, the red and lateritic soils cover a total area of about 110 million ha, out of which 70 Mha is occupied by red soil. The red and lateritic soils in India have developed under varying physiographic and climatic conditions in the tropical and subtropical climates with rainfall ranging between 600 to 4000 mm and mean annual temperature between 22 and 30°C with narrow differences between mean summer and mean winter soil temperatures (Ghosh, 2019). The productivity levels of these soils are usually of low order owing to various soil related constraints like acidic pH, restricted availability of nutrients like nitrogen, phosphorus and potassium, light texture, low cation exchange capacity, poor water retentivity, low organic carbon content etc. (Sarkar, 2013). Fish yield of the ponds located in these soil zones are generally lower as compared to the ponds situated in nearby alluvial soil zones (Bhowmick *et al.,* 2022). This has been attributed to the low range of primary food production in these ponds owing to the influence of some adverse soil properties on pond environment (Chattopadhyay and Banerjee, 2005).

In this study, an attempt was made to identify the major soil factors associated with primary fish food production in the ponds located under red and lateritic soil zone. It has been hypothesized that screening of a minimum data set of the identified key productivity determining soil factors and their management will help in improving the primary productivity and, thereby, the yield levels of these low productive fish ponds of the red and lateritic soil regions which occur extensively in tropical and sub-tropical regions.

Materials and Methods

Forty two bottom soil samples were collected from fish ponds situated in various red and lateritic soil zones of Bankura, Birbhum, Puruliya and West Burdwan districts covering the major stretch of red and lateritic soils in West Bengal, India at 86000'00"-- 89000'00" E longitude and 21030'00''— 24030'00'' N in latiitude (Fig. 1). Fish ponds were selected randomly, taking the help of local administration. Surface soils, up to a depth of 15cm, were collected manually while primary productivity studies were carried out in the surface water layer covering a depth of 30 cm. The collected soil samples were air dried, ground and sieved to 80 mesh size for the analyses of pH (1:2), organic carbon (Walkley and Black, 1934), available nitrogen (Subbiah and Asija, 1954), available phosphorus (Bray's extractant no.1), available potassium (Jackson, 1973), texture and available micro nutrients (Fe, Mn, Cu and Zn) following standard protocols. The pH was determined with the help of an electrically operated pH meter, nitrogen was estimated by Kjeltech apparatus, phosphorus was determined with a spectrophotometer and potassium was estimated using a flame photometer. Analyses of the micronutrients were carried out with the help of an atomic absorption spectrophotometer using DTPA extraction of these micronutrients as described by Lindsay and Norvell (1978).

Since most of these soil properties are likely to be influenced by submerged condition of the pond soils, the processed soil samples required for estimating parameters, other than texture and organic carbon, were incubated under submerged condition for 10 days using 1:10 soil water ratio for developing a semi-aerobic condition in the soil simulating to fish pond condition and then used for the estimations. Water samples of all the fish ponds were analyzed for gross primary productivity (GPP) values by incubating the fresh water samples in light and dark bottles and estimating the dissolved oxygen by following the principle described by Odum (1973). Statistical analyses of the results were carried out at three phases using SPSS software (v.21). During the first phase, correlation coefficients of different soil properties with the dependent variable GPP were estimated. The soil factors which came out to be significantly correlated with GPP of water were further selected for step down regression analysis with regard to GPP. This helped to develop several prediction equations to calculate the probable GPP values of water using the key soil factors. From these, the most convenient equation with minimum data set (MDS) was selected for predicting the on-farm GPP values. During the third phase, the path co-efficient analysis was adopted for assessing the results further. The precision of the most convenient equation in predicting the GPP of the fish pond water using only pH and available phosphorus values of bottom soils was also assessed through a study on eight fish ponds from the red and lateritic soil zones. Since the results of this assessment study could be