Application of Fertilizers for Sustainable Fish Culture

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I. INTRODUCTION

Fish culture/aquaculture is gaining increasing attention especially in the developing countries. Land based agriculture has probably reached its zenith of development which might be the reason of present day interest in aquaculture. The productivity of aquaculture system depends primarily on two factors viz. (i) the presence of good quality of fish food organisms and (ii) the maintenance of a congenial environmental habitat for the life and growth of cultured fish in the pond. Nutrients represent the natural fertility of the water on which primary productivity, production of fish food organisms and ultimately fish production depends. The increase of production beyond base level requires knowledge of nutrient requirements and ways to increase the nutrient levels.

Conventionally fish ponds in India are closed systems with no outflow and no exchange of water. Fertilization of fish ponds with organic (animal litter) and inorganic fertilizers is a common practice and appears to be very effective for increasing nutrient levels of fish ponds/fish production. Application of organic/inorganic fertilizers increase with each increase in the intensification of the system (Pekar and Olah, 1990; Steffens, 1990 etc.). Chemical fertilizers are also used to supply necessary nitrogen, phosphorus and potassium (NPK) in fish culture ponds. However, no standard procedures are available to decide the quantity of fertilizers to be added. Hence for the better understanding of production processes and to check pollution in fish culture ponds, there is a need to acquire knowledge about fertilizers used in fish culture ponds and their judicious application.

II. ORGANIC FERTILIZERS/ORGANIC MANURE

Organic fertilizers are mainly solid or liquid excreta of livestock animals (cattle, pigs, sheep, ducks, chicken), slaughter house wastes (rumen contents, blood etc.) compost and domestic or industrial (from agricultural industries) sewage water. The chemical composition of animal excreta is variable, depending not only upon the nature of feed ingested, but also on other ingredients added to form the final manure product, such as urine, straw litter, and/or excess feed. Moreover, they are characterized by a great variability in water and nutrient content. Their nutrient to dry matter content ratio is almost 20 to 30 times lower than that of inorganic fertilizers. Average chemical composition of excreta of common livestock animals are given in Table 1. Furthermore, digested manure like biogas slurry, are very good pond manures.

Table 1. Average composition of excreta of common livestock animals

Animal	Feaces to urine ratio	Humidity	Nitrogen (%)	Phosphorus (in % of P2O5)	Potassium (in % of K2O)
Cow-dung	75:25	85	4.0	2.7	3.4
Poultry waste	100	65	6.0	7.9	3.7
Piggery waste	53:47	85	4.7	4.3	2.7
Horse	75:25	75	2,3	1.3	1.4

III. METHODS OF APPLICATION OF ORGANIC WASTES

3.1 Keeping livestock in the vicinity of fish ponds

Keeping livestock in the vicinity of fish ponds obviates the need for extensive transport of manure and enables full utilization of the fresh manure and fodder remnants before losses due to biological degradation. Animals most commonly grown in conjunction with fish ponds are ducks and pigs and fresh duck manure and feed remnants being constantly added to the ponds. The husbandry of livestock other than ducks and pigs has not been widely integrated with fish farming due to more to technical problems of integration than to the suitability of their manures. In principle any intensive livestock unit could be integrated with fish farming to the mutual benefits of both units.

3.2 Transport of manure from livestock farms

Manures such as cow-dung is transported from the nearby areas and semi-dry manure is added in required amount to fertilize fish ponds.

3.3 Mode of application of manures to fish ponds

- Manures are usually broadcasted on the pond water surface. Manures could only be spread in water in small amounts. The spreading should be as homogeneous as possible over the whole surface. The better way is to dilute the manure in pond water (ratio 1:3 w/v) before spreading on to the surface of the water.
- Another way is to spread the dung or compost on the bottom of dried ponds before impoundment or even to work it into soil by shallow ploughing.

IV. DOSES OF ORGANIC MANURE

Most recommendations in aquaculture are empirical. Few studies have been carried out to determine the fertilizer dosages required in fish ponds for optimum pond productivity and fish production without adversely affecting pond ecology (Wohlfarth and Hulata, 1987).

Cow-dung (at 20,000 kg ha-1 y-1) and poultry manure (at 10,000 kg ha-1 y-1) are the most commonly used organic manures throughout the country, depending on their availability. In addition, sometimes inorganic fertilizers of nitrogen and phosphatic bases are used at 200-500 kg ha-1 y-1 (Shetty and Nandlesha, 1992). Alikunhi et al. (1955) who showed that average plankton production was higher in ponds manured at 11208 kg ha-1 y-1 than those pond manured at 16812 kg ha^{-1} y^{-1}. Hopkins and Cruz (1982) in their comprehensive studies on the use of pig, duck and poultry wastes in fish ponds also reported that an increase in the dosage of manures enhanced nutrient release, production of fish food organisms and fish yield. However, a further increase in the manure load beyond the optimum dose (optimum dose for pig 101-110 kg ha^{-1} d^{-1}, duck 82 kg ha^{-1} d^{-1} and chicken 100 kg ha^{-1} d^{-1}) resulted in lower fish growth and production, probably due to decrease in DO concentration.

Studies of Yadava and Garg (1992) revealed that with high doses of organic fertilizers (24000 kg ha^{-1} y^{-1}) cost of inorganic fertilizers and supplementary feed were reduced by about 50%. However, subsequent studies of Garg and his co-workers have shown that with continuous use of high dosages of organic fertilizers, an accumulation of toxic metabolites in the water column and pond sediment occurs, not only reducing fish production but also deteriorating the pond environment. Garg and Bhatnagar (1996) showed that average plankton production and fish biomass were higher when cow-dung was used at 10000 kg plus 1500 kg of single superphosphate (SSP) ha^{-1} y^{-1}, than when used at higher rates (20000 kg of cow-dung plus 3000 kg of SSP ha^{-1} y^{-1}). Subsequent studies (Garg and Bhatnagar, 1999) revealed that 15000 kg ha^{-1} y^{-1} of cow-dung appears to be optimum dose when used alone under fresh water conditions.

Garg (1996) further reported that the rate of mineralization and degradation of organic manure is slow in saline waters hence low doses of fertilizers are required Garg *et al.* (2004) found 7500 kg ha^{-1} y^{-1} of cow-dung as optimum dose for inland saline groundwater ponds for optimum pond productivity, where water salinity varied between 12.5 to 20.0 ppt. Garg and Bhatnagar, 2001 used 4 different fertilization frequency and observed highest fish biomass value and specific growth rate ,net primary production in those pond which received fertilization twice in a month.

Kanwal et.al 2003observed higher fish production in three fish species in pond which was manured with dry cow dung than pond which was manured with fresh cow dung. A significant difference among the weight gain in fishes under control and treated ponds. The difference in average body weights of three fish species were significant which showed that manure has a positive affect on the growth performance of major carps.

According to Godara *et al.,*2015, use of vermicompost in pond waters at 10,000 kg ha^{-1} $year^{-1}$ seemed to be the best among the six treatments. This was evident in case of DO, alkalinity, hardness, light penetration, free carbon dioxide, phytoplankton's and zooplanktons. For other parameters are also more favorable and resulted vermicompost at 10,000 kg ha^{-1} $year^{-1}$ came out to be the best among the six treatments.

V. INORGANIC FERTILIZERS

Inorganic fertilizers are characterized by their composition of primary nutrients, i.e. nitrogen, phosphorus and potassium (NPK) in mineral form. Potassium is seldom considered, as it is usually accepted that the needs for this element are satisfied by the amounts naturally contained in water. Therefore, potassium fertilizer is usually not added, it is the N:P proportion that matters.

VI. NITROGEN FERTILIZERS

Nitrogen, along with carbon, oxygen and hydrogen, is one of the four major elements, of which organic molecules are composed, and is therefore quantitatively important in living matter. Nitrogen needs of animals are met principally by proteins, while plants use mineral nitrogen compounds. Nitrogen assimilation occurs simultaneously with that of other nutrients, in accordance with a given proportion between nutrients. The carbon-nitrogen phosphorus ratio (C:N:P) most commonly used with reference to algal needs is the Redfield ratio of 106:16:1, though other ratios are mentioned, such as a C:N:P of 100:12:1 (Blazka *et al.,* 1980). This proportion is not fixed, as the levels of nitrogen and phosphorus in algal cells change constantly, through assimilation and other metabolic activities. Many inorganic nitrogen fertilizers are available. Important are listed below :

Ammonium sulphate	$(NH_4)_2 SO_4$	21%
Ammonium nitrate	NH_4NO_3 or NH_4NO_3+ dolomite	33-34%
Urea	$CO (NH_2)_2$	42-45%

6.1 Mode of action of nitrogen fertilizer

The addition of nitrogen fertilizer to a pond is followed by short-lived peaks in ammonium and nitrate. The disappearance of inorganic nitrogen added to water could result from biological immobilization (nitrogen uptake and incorporation into organic compounds), denitrification of nitrate, transformation of ammonium into ammonia and subsequent gaseous escape of the latter, or nitrification of ammonia, followed by denitrification. Amounts of nitrogen sorbet onto and accumulating in the sediment are relatively small. Gaseous escape of ammonia is restricted to periods of high pH and does not appear to be significant.

6.2 Phosphorus fertilizers

Among different fertilizers, however, use of phosphorus is recognized to be the most critical in improving productivity of fish ponds. The significant role of phosphorus fertilizer in pond productivity is attributed not only to the significant role of this nutrient element in multiplication of primary fish food organisms through cell division but also to the fact that a large share of the added phosphorus get fixed into insoluble forms in the bottom soils of the ponds. Most of the added phosphorus gets fixed into insoluble forms shortly after its application as fish food fertilizer, leaving only a small amount of the added nutrient in available forms for the benefits of primary producers (Chattopadhyay *et al.,* 2003).

6.3 Phosphorus fertilizers available

Table 2. Commonly used phosphate fertilizers

Fertilizer name	**Chemical formula**	**Percentage in P2O5**
Superphosphate	Ca (H2PO4)2 Ca HPO4 Ca SO4	16-50
Triple superphosphate	Ca (H2 PO4)2	44-47
Ammonium superphosphate	NH4H2PO4 Ca H PO4 (NH4)2 SO4	16-18
Ammonium phosphate	(NH4)4 P2O7	56-60
Diammonium phosphate	(NH4)2 HPO4	
Calcium metaphosphate	Ca (PO4)2	62-63

6.4 Mode of action of P fertilizers

Phosphorus fertilizers added to the water interact with other water features, particularly with calcium carbonate in alkaline water and with iron and aluminum in acid water. As a result of addition of P fertilizers in ponds a rapid increase n o-PO_4 concentration in water occurs, which disappears after a short time. Disappearance of phosphorus is the result of absorption by bacteria, macrophytes and phytoplankton, and adsorption by organic colloids in solution or in suspension in water, as well as adsorption by sediment or interaction with ions in water. The significant role of phosphorus fertilizer in pond productivity is attributed not only to contribution of this nutrient element in multiplication of primary fish food organisms but also to the fact that a large share of the added phosphorus gets fixed into insoluble forms in the bottom soils of the ponds, and higher magnitude of phosphorus fixation is reported under alkaline environment. Thus studies on the judicious application of phosphatic fertilizers should be given special attention to prevent a severe problem in almost all the fish ponds. Phosphorus fertilizers are normally applied at 8.75 to 17.5 kg P_2O_5 (eq.) ha^{-1} w^{-2} for obtaining optimum benefits.

6.5 Use of potassium in fish pond fertilization

Inspite of being the third major nutrient element in plant nutrition, potassium (k) has not been included in fish pond fertilization program. Restricted use of K as a fish pond fertilizer may be attributed to two reasons:

- Concentration of K in fish is much less than nitrogen and phosphorus.
- The bottom soil of a productive fish pond usually exhibits heavy texture, good organic matter status and neutral to alkaline pH range. These properties led to the occurrence of moderate to good availability of K in pond soils.

However, several studies have been carried out to assess the effect of K fertilizer on production of primary fish food organisms in the presence of high doses of N and/or P fertilizers and observed that inclusion of K in the fertilization schedule tended to increase the primary production over the series with N and/or P only. Hence 'K' should also be included in pond fertilization schedule.

Adoption of comprehensive nutrient management programs through inclusion of all three major nutrient elements viz., N, P and K is likely to result to generating as well as sustaining maximum benefit from such fertilization practices. Although positive effects of balanced uses of fertilizers have been recognized by large sections of agriculturists of the country, this concept has not reached the aquaculture sector so far. Recent thrust on intensification of various culture operations in the field of fish production is likely to lead to larger uses of nutrient inputs in fish culture. If the importance of balanced fertilization is not conceived at this stage, it is probable that the culture systems will start showing the ill effects of imbalanced fertilization in near future. It is the appropriate time to generate awareness about the beneficial effects of balanced uses of various fertilizing elements for developing improved as well as sustainable aquaculture practices in the country.

VII. CONCLUSION

The tropical aquatic environment of ponds, tanks, and impoundments, both freshwater and brackish water, need in-depth studies on the mechanisms of nutrient sedimentation and its release for enhancing bio productivity and optimizing the result of applied inputs. There is also a need for standardizing the assessment techniques for water quality and pollution load characterization for culture environment of different systems and commodities. The major areas of research are :

- Development of standard methodology for monitoring pollution status and water quality.
- Studies on mechanism of nutrient release from pond sediment.
- Assessment of interaction between applied inputs and nutrients locked up in pond sediment.
- Relationships of abiotic factors and fish stocks for the determination of optimum water quality requirement in different agroclimatic conditions.
- Eutrophication and pollution.
- Studies on optimum dosages determination for organic manure and inorganic especially P fertilizers.
- Frequency of application of fertilizers in brackish waters.

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