The environmental responsibility of feed producers

Interaction between food and water

Photo: Environmental Justice Foundation

The importance of nitrogen : phosphorus ratio

By Bernard Devresse, Director, Bern&Roc Aquaculture ltda, Natal, RN Brazil.

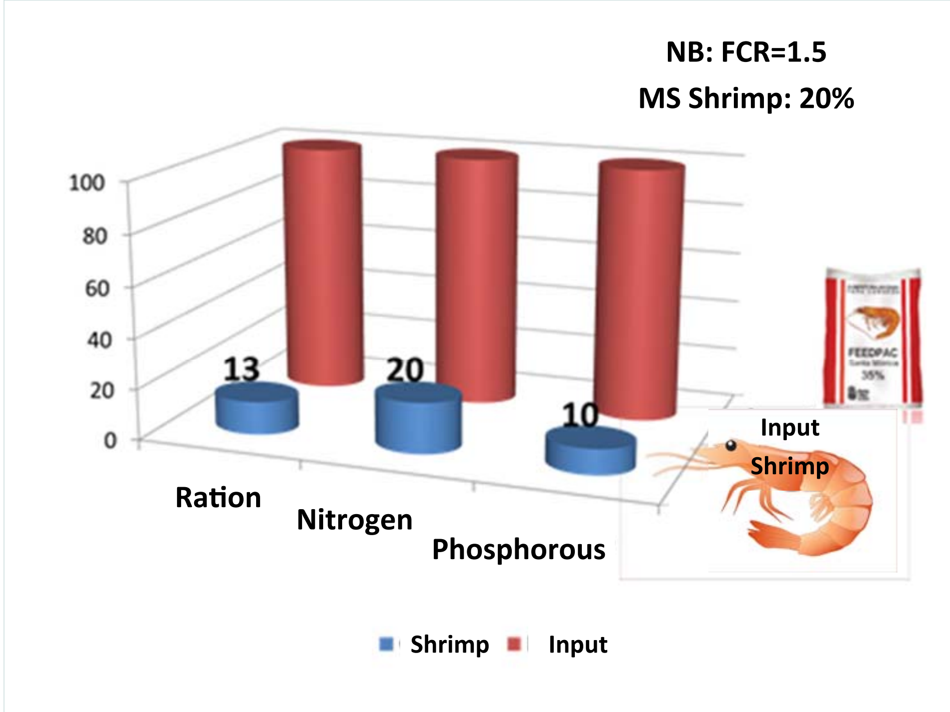
Shrimp farmers are subject to pressure to fulfil environment regulations and today regulating bodies are demanding more often the implementation of complete recirculation systems or are imposing very limited water discharge into the environment.

Shrimp farmers are too often seen by the public or by authorities as polluters or mangrove destroyers. They bear the role of the bad guy. While there may be some truth in everyone's point of view, there is an important factor that has often been overlooked: the feed. The main input of a shrimp farm is the feed and the shrimp farmer has no control and barely any understanding of feed composition.

If we all agree that feed is without a doubt the main indirect contributor to organic and mineral discharge in the environment, it is also - and by far - the biggest cost of the farm operation. Farmers will naturally limit its use to reach maximum growth and the lowest feed conversion. Therefore we can assume that limited amounts of feeds, if any, are wasted by farmers because this would bring their operation serious financial loss.

So if farmers do not use more feed than they should, what else can they do to limit nutrient discharge? Well, even if they enhance organic matter mineralization and denitrification processes, there is a limit to what they can do.

On the other hand, feed producers have to realize that they do have an important responsibility in protecting the environment. They are responsible for providing the farmer a feed that enables them to respect established rules while maximizing feed utilization and reducing feed wastes. Several rules are already enforced in some European countries (Directive 200/60/EC and later updates), which limit the inclusion of some key elements involved in water eutrophication. This short paper presents some basic interactions between life and feed composition and some suggestion to reduce the impact of shrimp farming on the environment.



Feed wastes are inevitable: Some fundamental rules of biology

Shrimp, like any living animal, will use part of the energy ingested to sustain its metabolism and part for growth. A small part (around 10%) will be excreted as undigested material.

Even if all feed offered is eaten, a shrimp will typically incorporate in its body an average of 13% of the organic matter ingested, 20% of the Nitrogen and 10% of the Phosphorus. The difference will stay in the farm or in the environment.

Environmental regulating bodies are requesting the farmer to recirculate the water or to very significantly reduce the discharged wastes. But this is not an easy task.

" … Nitrogen : Phosphorus ratio in life is quite constant. It is about 8:1. This is true for bacteria, algae or shrimp (even for humans). "

Life has a logic that we need to understand. Put very simply here, life runs around five main elements. These are Carbon, Oxygen, Hydrogen, Nitrogen and Phosphorus. Organic matter typically contains 45-55% carbon, 35-45% oxygen, 3-5% hydrogen, 1-4% nitrogen and 0,1-0,5% phosphorus. It is interesting to note that Nitrogen:Phosphorus ratio in life is quite constant. It is about 8:1. This is true for bacteria, algae or shrimp (even for humans).

In the course of mineralization processes, the first three elements will easily be oxidized into Carbon dioxide (CO2) and water (H20), which are harmless. On the other hands the other two will be typically be present as nitrates and phosphate salts that are direct contributors to autotrophic life, or fertilizers. If they are present in abundance and are not within the right balance, they will lead to eutrophication, with all the consequences for the wild life and environment.

In other words, the microscopic life (bacteria and algae) within and outside a farm will need to be presented Nitrogen and Phosphorus at the right proportion of 8:1 if we expect to recycle the water and its nutrients completely. If there is an excess of one or the other element, it will accumulate and cause imbalance. The farm will not be able to run in complete recirculation for very long before a serious excess of one element (often phosphorus) will provoke a total collapse of the activity.

Concept of partial or total reciculation

Typically, discharged water of shrimp farms will contain an excess of phosphorus. When phosphorus is in excess and Nitrogen is in short supply, blue green algae tend to thrive because they can assimilate nitrogen from the air and outcompete all other form of life. Blue green alge is not good news for shrimp farms as they will cause off-flavors in shrimp or even produce toxins.

Shrimp farm effluents typically contain a N:P ratio of 3:1 to 1:1 with levels of phosphorus ranging from 0.01 to 1.0 ppm. NB: eutrophication is likely at phosphorus levels above 0.1 ppm .

Freshwaters are more vulnerable to phosphorus accumulation than seawater

It is also well documented that some 50% of the phosphorus concentrates in pond bottom sediments. A large part of the phosphorus present in the sediment is not reactive or available to life. Indeed, under slightly alkaline conditions prevailing in seawater (pH 8,5 and higher), phosphorus will precipitate with Magnesium and Ammonia to from a stone called Struvite ($NH_4MgPO_4 \cdot 6H_2O$). If pH remains alkaline, struvite is a stable form of phosphorus that is unavailable to algae or bacteria and does not form part of the reactive phosphorus. Struvite does not form in freshwater because fresh water does not contain significant concentrations of Magnesium. Freshwater farms will therefore be more vulnerable to phosphorus accumulation than seawater farms.

Total recirculation is not an easy job and what we can do about it. So total recirculation will work if there is a balanced supply of all elements and in particular C:N and N:P to the microbial flora responsible for the mineralization and recycling of organic matter (feces, uneaten feed, etc.). Bioflocers are well aware of the role of carbon as energy source to bacteria. They need to keep the balance between Carbon and Nitrogen around 20:1 to mineralize organic matter and detoxify ammonia and nitrites. They also need to keep the balance between Nitrogen and Phosphorus around 8:1 to avoid phosphorus accumulation and make total recirculation possible.

One might obviously think of adding Nitrogen in the water to correct the imbalance. This is indeed a possibility and fertilization with Calcium nitrate or urea is well known practice in shrimp farming. However under total or partial recirculation conditions, this will only contribute to loading more nutrients in a farm already faced with too much of it.

The other way is to correct the N:P of the feed. The Nitrogen : Phosphorus ratio of a feed is typically 4:1. A feed will contain an impressive amount of 1.0 to 1.5% phosphorus while a shrimp only needs 0.3-0.5%. In other words shrimp feeds are typically formulated with an excess of low quality, poorly available phosphorus. 90% of the phosphorus of the feed is not accumulated by the shrimp and is released into the environment. This places the whole shrimp farm ecosystem under serious pressure and the shrimp farmer has no means to act on this.

This is the responsibility of the feed producer. The feed producer should consider adapting feed formulation to decrease phosphorus inclusion in the feed. This is already current practice in countries such as northern European countries. These countries have adopted measures to protect their freshwater rivers from eutrophication by limiting the amount of phosphorus in the feed. The same can be done for shrimp feed without causing any harm to feed performance or increasing feed costs.

Several measures can be taken simultaneously to decrease the phosphorus level in the feed.

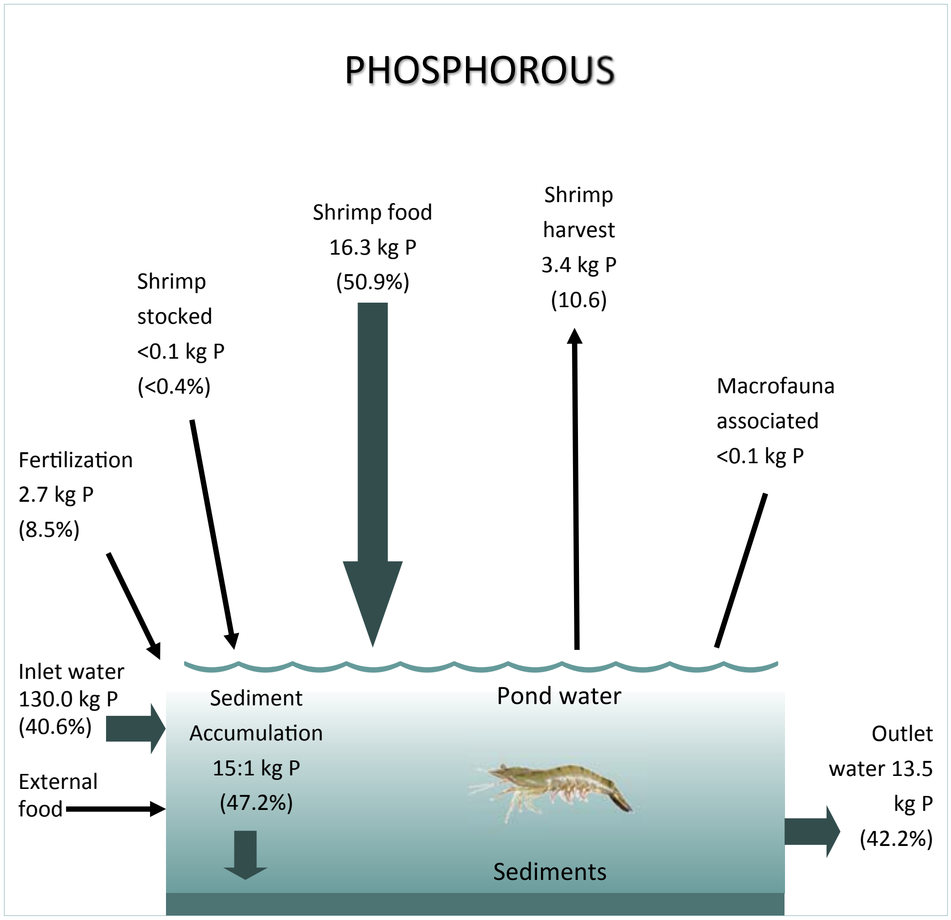


Figure 1. Phosphorus input and output in a traditional shrimp farm in the gulf of Mexico.

Paez-Osuna, F., Guerrero-Galvan, S.R., Ruiz-Fernandez, A.C., 1999. Discharge of nutrients from shrimp farming to coastal waters of the Gulf of California. Marine Pollution Bulletin 38, 585–592.

Table 1. Phosphorus availability of several mineral feed ingredients

(Davis et Arnold 1994)	Phosphorous Availability
Calcium Phosphate tribasic	9%
Calcium Phosphate dibasic	19%
Calcium Phosphate monobasic	46%
Sodium Phosphate monobasic	68%

Davis, D.A. and Arnold, C.R. , 1994. Estimation of apparent phosphorus availability from inorganic phosphorus sources for Panaeus vannamei. Aquaculture 127, 245-254.

(1) Replace the use of Calcium phosphate salt by Sodium or Potassium phosphorus salts, which are more available. The use of phosphoric acid is also an option.

(2) Limit the inclusion of animal proteins such as fish meal or meat meal that contain large amounts of phosphorus rich ashes that are basically unavailable for the shrimp.

(3) Use the enzyme phytase to increase the availability of phytic acid present in vegetable ingredients. Some cereals brands are naturally very rich in Phytase and can contribute to increasing the availability of phytic acid.

(4) Reduce the content of soluble or reactive calcium, which directly impairs phosphorus availability in shrimp.

In summary, keeping the environment clean is an important task for everyone. It is not merely a problem for shrimp farmers. It is a collective responsibility involving all levels of human activity. It goes from the use of phosphorus based soaps or detergents, agricultural fertilizers through the responsible us of fossil fuels, etc.

Feed producers have their role to play in this noble quest by correcting the Nitrogen : Phosphorus ratio in their feed thanks to the use of better sources of phosphorus.

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