# REUSE OF WATER FROM CATFISH PONDS

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**Abstract.** Most channel catfish *(Ictalurus punctatus)* production in the U.S. is in ponds varying in sizes from 1 to several ha. Large volumes of high quality groundwater are needed for catfish production. The ponds are periodically drained to adjoining streams during seining and harvesting and then refilled with groundwater. There are concerns that the groundwater resources are depleting rapidly. Hence, water reuse and conservation techniques are needed for fish as well as crop production.

We have investigated a catfish production method in which ponds with a high stocking density are periodically drained and the effluent is applied to soybeans (*Glycine max.* L.) as irrigation water. Since the effluent contains nitrogen and phosphorus, no additional fertilizer was applied to the crop. The effluent quality was monitored for ammonia, nitrate, nitrite, TKN, and total phosphorus as well as for pH and COD.

The preliminary results indicate that this production practice is beneficial for producing fish in ponds stocked with a high density (22,000 to 66,000 fish/ha). The soybean yield was more because of irrigation. However, there was no added benefit from application of effluent compared to the groundwater. The integrated fish and crop production system minimized the drainage of ponds, thus avoiding the addition of COD, phosphorus, and nitrogen to natural waters.

## INTRODUCTION

Aquaculture is an expanding agricultural industry in the southeastern United States. The U.S. farm value of channel catfish is around 290 million dollars, Georgia's share being 10 to 12 million. High quality plentiful groundwater is primarily needed for catfish production. Each unit area of catfish pond presently uses as much as 1.2 m of water during the growing season. Channel catfish was grown in about 57,000 ha in the U.S. in 1989; using about 690 million $m^3$ of water.

Catfish ponds are periodically drained for water exchange and during harvesting into adjoining streams. However, the effluent contains high levels of nutrients and suspended matter and its discharge into streams and rivers is a growing concern. Also, large volumes of groundwater may not be readily available because of depleting resources. According to Wax and Pote (1990) the potential for groundwater conservation for catfish production ranges from 65% to 82%.

### Water Conservation Research

Research related to water conservation and water reuse has generated considerable interest among producers and scientists alike in the recent years. Scientists are investigating various production methods in order to manage the aquacultural effluent efficiently and also to provide reasonable returns on producers' investments. Wang and Jakob (1991) used shrimp pond water to feed oysters and oyster's depuration water to irrigate the shrimp pond in integrated oyster and shrimp production system. Lawson et al. (1983) found that crawfish ponds should be flushed a the rate of 935 L/min/ha for maintaining good water quality for optimum production. Lorio et al. (1991) recirculated pond water with biofiltration in intensive catfish production system. Their findings indicate that such an approach is a viable technique for catfish production. Hollerman and Boyd (1985) stocked catfish ponds with 9,000 fish/ha and unlike the customary practice, did not flush them over a period of 3 years. The water quality in their technique remained good for fish production. Both of these approaches provided much needed information on water conservation in catfish production systems.

Water quality in catfish ponds subjected to high stocking density selective harvesting production practice was monitored in 1991. The results indicated that the nutrient concentrations in pond water were within acceptable limits for catfish production (Ghate et al., 1992).

### New Method Developed

Considering the importance of high stocking density selective harvesting technique and the current trends toward water conservation and reuse, a new method of catfish production was designed in which the effluent was used as irrigation water for crop production. Ponds were stocked with high densities and selectively harvested over the growing season. In addition, ponds were periodically drained and the effluent was applied to crops as irrigation water. Then the amount of drained water was refilled with groundwater.

It is hoped that production information gathered from this practice may help in developing a system in which fish and crop productions will be integrated, groundwater conserved and pond effluent reused.

## MATERIALS AND METHODS

The objectives of this research were to (1) characterize the various water quality parameters in the pond effluent which can be used as irrigation water for crops and (2) estimate their impact on integrated crop and fish production system.

Nine 0.1 ha earthen ponds were filled to a depth of 1.2 m with well water and stocked with 10 to 15 cm long catfish fingerlings at the rate of 22,000, 44,000, and 66,000 fish/ha in three replicates arranged in a randomized completer block design. Ponds were fed at the daily feeding rate of 3% of fish body mass determined by frequent sampling. Ponds were continuously aerated and oxygen levels kept above 4 mg/L at all times. Beginning with July, fish were selectively harvested (approximately 0.25 kg) during the first week of each month. The last harvest was during the first week of November.

Ponds were drained several times and effluent applied to soybean crop planted in a nearby field. Figure 1 gives the layout of the facility. Drained ponds were immediately filled with well water. The number of drainage events were in proportion to the stocking densities: the high density ponds were drained 11 times, the medium density 5 times and the low density 2 times. The high density ponds were thus drained approximately at 2 week interval (Table 1). The amount of pond drainage was arbitrarily selected and was equal to 25% of its volume or about 30 cm of water depth.

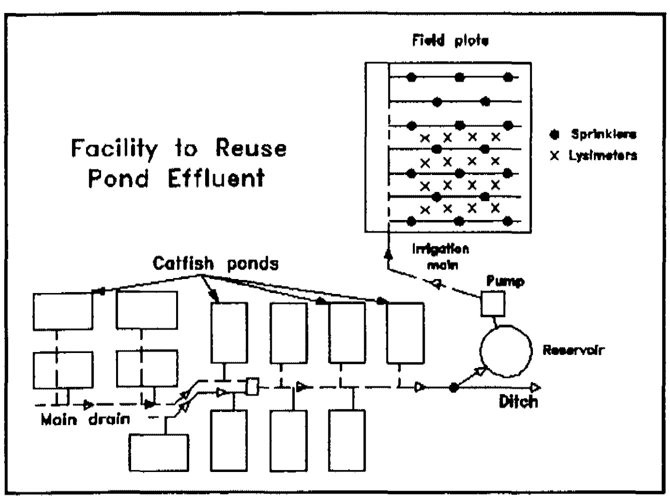


**Figure 1. Integrated fish and crop production facility.**

TABLE 1. Stocking density, feed, and number of drainage events during 1992 catfish growing season.

| Stocking Density | No. of Fingerlings per ha | Total Feed Applied, kg/ha | Final Yield kg/ha | No. of Drainage and Refilling | Dates of Drainage |
|---|---|---|---|---|---|
| Low | 22,000 | 11,111 | 2,564 | 2 | Jul 15<br>Sep 9 |
| Medium | 44,000 | 15,662 | 4,360 | 5 | Jul 1,19<br>Aug 25<br>Sep 22<br>Oct 20 |
| High | 66,000 | 19,965 | 4,496 | 11 | Jun 11,24<br>Jul 8,22<br>Sep 1,15, 29<br>Oct 13,27 |

Soybean cv. Delta Pine 3627 was planted in the first week of June and harvested in the first week of November. The crop was planted with a conservation tillage planter and no fertilizer was. Twenty-four (6 reps x 4 treatments in a randomized completer block design) 13 m x 13 m field plots were irrigated with the drained effluent. Control plots were irrigated with well water on the same days when the high density effluent was applied. Plots were sprinkler irrigated for about 3 h which amounted to about 3 cm of water during each application.

Lysimeters were placed in each treatment (Figure 1) at the depth of 60 cm in four replications. Vacuum was applied to lysimeters 24 h after the irrigation event and water accumulated in the lysimeters was collected 24 h later. Soybeans were harvested from the middle 4 m x 10 m area of each plot for yield and moisture content determination.

Effluent and lysimeter samples were analyzed for pH, COD, total ammonia-N (TAN), nitrite-N, nitrate-N, total phosphorus, and total Kjeldahl nitrogen (TKN). Effluent samples were also analyzed for total and dissolved solids. Most analyses were completed within 24 h of sample collection. Samples were preserved by acidifying with concentrated sulfuric acid (2 mL/L) to adjust pH to less than 2.0 and stored at 4° C until TKN and total phosphorus analyses could be completed.

Nitrate, nitrite, TAN, and were determined using commercially available spectrokit reagents (Milton Roy and HACH brands) and a Bauch & Lomb spectrophotometer 20. COD was determined with a HACH digestion system (HACH, 1989). Total phosphorus and TKN were found by digestion on a Technicon Kjeldahl block digester and analysis with a Lachat flow injection autoanalyzer. Total and dissolved solids in effluent were determined by following the procedures outlined by Boyd (1979). The pH was determined by using a pH electrode and an Orion meter.

## RESULTS AND DISCUSSION

Neither nutrient nor solid content in the effluent was affected by the density treatment. Mean values of TKN and total phosphorus were from 9 to 12 mg/L and 0.2 to 0.6 mg/L respectively. The COD amounts varied from 56 to 108 mg/L. The average TAN values in the effluent were from 0.4 to 1.24 mg/L and total solid contents 139 to 206 mg/L. These values are similar to the ones reported by some other researchers under different types of production practices for catfish production (Boyd et al. 1979; Ghate et al. 1992; Tucker and Lloyd, 1985) and were not detrimental to fish growth or survival.

Since effluent contains nitrogen, crops can benefit if it is used as irrigation water. From the TKN concentrations, it appears that the total amount of nitrogen available for crops varied from 0.9 to 1.2 kg N/ha from each cm of water applied. If the average irrigation amount is assumed to be 30 cm, then the available nitrogen would be from 27 to 36 kg/ha. This represents a significant portion of nitrogen requirements of several crops including cotton, fescue pasture, and cucumber (Plank, 1989).

Soybean yield of 3.6 t/ha was double the average yield in Georgia, but was not affected by the effluent treatment. The higher yield was due to irrigation. The main advantage of draining and refilling practice was on keeping good water quality for fish production under high intensity. Feeding rates in the ponds were quite high, however, the effluent quality did not deteriorate. Groundwater which would have been used to irrigate the crop was used for filling the ponds. It also appears from the quality of the effluent that the unused portion of the drained pond water might be recirculated back to the ponds for fish production with minimal purification. The purification process may involve mostly a process for separating solids from the effluent. The other water quality parameters such as TAN and COD were present in small concentrations and hence, simple techniques such as aeration may reduce their amounts considerably.

## CONCLUSIONS

Integrated fish and crop production system may be a viable solution to conservation or effective of groundwater. Frequent draining and refilling would not deteriorate the water quality in intensive catfish production system. Effluent can provide considerable amount of nitrogen for crop production if used as irrigation water. The effluent drained in excess of the irrigation requirements may be recirculated back to catfish production ponds. The integrated fish and production system would not only conserve the groundwater and reuse the pond effluent but also minimize the effluent discharge to natural streams and rivers. The effluent discharge to natural waters will be almost eliminated if the portion of the drained effluent in excess of irrigation is reused for fish production.

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