sustainable sanitation alliance

Reuse of human urine in aquaculture Kalyani, West Bengal, India

Fig. 1: Project location

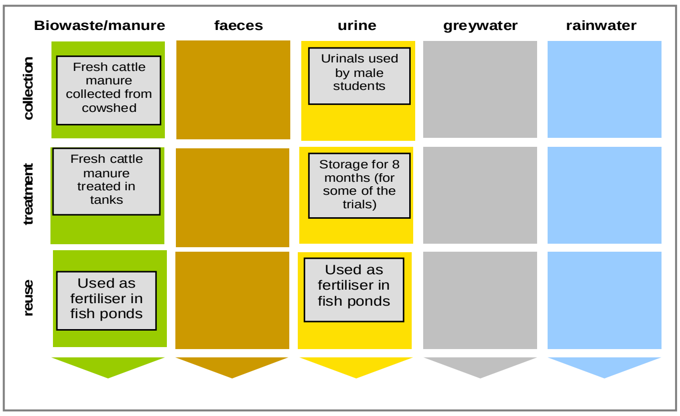

Fig. 2: Sanitation components used in the project

1 General data

Type of project:
Pilot research study of the reuse of human urine in carp farming from a community based sanitation in West Bengal, India

Project period:
Project start: May 2008
Project end: October 2008 (end of research phase)

Project scale:
Number of inhabitants covered: 250 (urine collection only)
Total investment (in EUR): 6,000 (for research equipment and labour)

Address of project location:
International Centre for Ecological Engineering, University of Kalyani, Kalyani -741235, West Bengal, India

Planning institution:
Same as address for project location

Executing institution:
Same as address for project location

Supporting agency:

German Federal Ministry for Economic Cooperation and Development (BMZ) via German Technical Cooperation (Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ))

2 Objective and motivation of the project

The experiments described in this document aimed to evaluate the fertilising value of human urine in carp farming. They explored the possibility of using human urine as fertiliser in the commercial production of economically important algae for human use, and zooplankton and benthic animals for fish farming.

3 Location and conditions

Kalyani is a new satellite town with a population of around 100,000 located on the fringe of Calcutta Municipal Corporation. It is an academic hub with 4 universities, 2 engineering colleges and one medical college. Most of the inhabitants are academics belonging to the upper middle income group.

Fig. 3: Urine-fed experimental aquaculture tanks (3 m × 1. 5 m × 1 m ; volume: 4500 L) (source of all photos: B. B. Jana, Oct. 2008).

Kalyani in West Bengal state is a well planned modern town with a centralized sewer system. The local climate is sub tropical and humid with temperatures fluctuating from 10–40 °C. Annual rainfall is around 1500 mm with 75% of this falling during the rainy season. Fish farming is a common source of income in rural areas with pond soil ranging from loamy to clayey. Paddy farming, horticulture and vegetables are the main agricultural activities and the local Agricultural University offers technical support for the introduction of novel farming techniques. The experiments were carried out at the

International Centre for Ecological Engineering, University of Kalyani, India.

4 Project history

Wastewater-fed aquaculture has been a major research area at the International Centre for Ecological Engineering, at the University of Kalyani. In the past, the fertiliser potential of commonly used animal manure which is easily available to farmers at cheap rate has been evaluated for aquaculture. Encouraged by a published paper (see Section 13 for details) on the experimental use of urine for the mass production of zooplankton, it was decided to extend the experiment with financial support from GTZ, Germany, to include carp production.

The results from the experiments will be of interest to fish farmers who could replace expensive chemical fertilisers with human urine. Moreover, chemical fertiliser may cause ecological imbalances if used wrongly. However, more careful studies are still needed to assess the hygienic risk of fish raised in a urine-fed system.

5 Technologies applied

The study used groundwater stored in 4500 L holding tanks. Fish growth in such farm ponds is dependent upon the input of macro and micro nutrients in the form of either chemical fertilisers or manure. Optimum levels of major nutrients such as phosphate, nitrogen and carbon, and water quality parameters, such as pH, dissolved oxygen, alkalinity, etc play a vital role in fish production. It is thought that human urine, containing all the essential nutrients for phytoplankton production, can play an important role at the base of the grazing food chain for farmed fish.

6 Design information

In order to collect the urine at the university, where the experiments took place, separate plastic pipes were installed at the water-flushed urinals used by the male students. Through these pipes urine was directed into 10 L plastic containers. During this procedure urine was not diluted with water, since the water was blocked from flushing into the urinals, while the urine accumulated in the container below. After collection, the urine was transferred into tanks manually. Adequate precautionary measures with gloves and masks were taken to avoid any kind of contamination during handling of human urine in the experiments

The urine was applied diluted, as high dosages of urine caused severe fish mortality in pilot studies. Fresh urine without storage and 8 month old stored urine was applied to the culture tanks in two different dilutions: 0.01% and 0.02%[1]. The dilution occurred directly in the 4500 L tanks after adding the urine. The 0.01% dilution was applied every week, whereas the 0.02% dilution was applied every two weeks.

In the first set of tests, 18 tanks, each of 4500 L volume, were provided with dry soil and filled with groundwater (pH 7.2 -7.4) a week prior to the experiment six treatments were carried out in triplicate (see Table 1):

a) 0.01% urine (aerated)
b) 0.01% urine
c) cattle dung alone (1.8 kg/tank)
d) iso-nitrogenous (315 g cattle dung + 315 ml urine)
e) iso-phosphorus (160 g cattle dung + 333 ml urine)
f) control (nothing added, not aerated).

A diffused air system was used to deliver air to the aerated tanks 30 minutes every second day using an air compressor.

Water quality, nutrient parameters, and production of phytoplankton and zooplankton were measured in treatment tanks to assess the fish yield in different treatments.

The total amount of nutrients added to each tank per week under designated treatments was as shown in Table 2.

Fig. 4: Collection of undiluted fresh human urine from water-flushed standard urinals by blocking water flush during urine collection.

Table 1: Experimental protocols followed.

	Human urine (aerated) (a)	**Human urine (b)**	**Cattle dung (c)**	**Iso-N (d)**	**Iso-P (e)**	**Control (f)**
Human urine	500 ml	500 ml	-	315 ml	333 ml	-
Cattle dung	-	-	1.8 kg	315 g	160 g	-

[1] 0.01% (or 0.02%) dilution equates to 0.5 L (or 1 L) undiluted urine added to 4500 L water tanks.

Fig. 5: Collection of samples from experimental tanks (3 m x 1.5 m x 1 m; volume: 4500 L).

Table 2: Total amount of nutrients added in different treatments employed[2] (no nutrients added in control (f)).

Nutrients input	Treatments				
	urine (aerated) (a)	Urine (b)	Cattle dung (c)	Iso-nitrogenous (d)	Iso-phosphorus (e)
Carbon (mg)	15	15	252	53.55	32.39
Nitrogen (mg)	2.5	2.5	5.4	2.51	2.14
Phosphorus (mg)	0.22	0.22	1.58	0.39	0.28

A second set of tests was used to examine the treatment response. The experiment was performed in outdoor tanks using three replications i.e., three tanks were used for each treatment to observe the effects of using fresh and stored urine.

Fig. 6: Application of urine.

[2] Different nutrients dose used in order to maintain the same level of nitrogen (iso-N) or same level of phosphorus (iso-P) between the cattle dung treatment and mixed treatment with cattle dung and human urine.

7 Type and level of reuse

Fresh human urine was collected from the urinals used by the male students and fresh cattle dung was procured from a local source. Human urine and other combinations of fertilisers were applied in the tanks every week.

In all the tests, advanced fry of fish with diverse feeding habits such as catla, rohu, mrigal, bata, tilapia and freshwater prawn were stocked together under polyculture. The stocking density was 22 per tank (equivalent to 48,000 / ha). The urine served as basal manure that upon degradation triggers and sustains phytoplankton production in the grazing food chain of fishes.

Heterotrophic bacterial loads which developed in the urine-fed system were also a source of food for the growing fish. No supplementary feed was used during the growth trial. The duration of the culture was 120 days for the first trial (for fresh urine) and 110 days for comparison of fresh and stored urine in the second trial.

There was considerable variation in the growth of the different species of cultured fish. For example, rohu showed better growth in urine-fed treatment compared to cattle dung, although the total fish yield for cattle dung was higher. The total fish yield in the iso-nitrogenous and iso-phosphorus treatments ranked second and third respectively though the differences between them were not significant. Likewise, fish yield in the direct urine-fed treatment was not significantly different from mixed treatment with iso-phosphorus.

As aeration started in mid-phase of the culture, no increase in fish growth was observed in this treatment. No significant difference in fish yields between the aerated and urine-fed treatment or between iso-nitrogenous and iso-phosphorus conditions were observed (Figure 6). This suggests that mixed treatment charged with urine might be useful for the culture of carp and especially for rohu in all the urine-fed treatments.

The results of the first tests showed that fish yield in the direct human urine-fed treatment ranked second to cattle dung treatment, but it was significantly higher than the control and, therefore, encouraging.

For the second tests, the comparison of fish yield for stored and fresh urine treatments showed that **yield was significantly higher when stored urine was used**. Because the yield was higher in stored urine-fed treatment due to more nutrient conversions and less ammonia toxicity. The yield obtained in mixed treatment of fresh and stored urine was intermediate in between (Figure 7).

From the results of initial bacteriological analysis, it can be stated that fish culture can be carried out using human urine as fertiliser. The counts of *E. coli* found in the water of the urine treated tanks remained within permissible limits for wastewater aquaculture. However, further studies in this direction are necessary.

These studies were confined to examining the fertiliser value of human urine but not thoroughly extended to pathogenic bacteria and other hazards analysis that may reflect the microbial contaminations through the food chain, if any. Therefore further studies are needed.

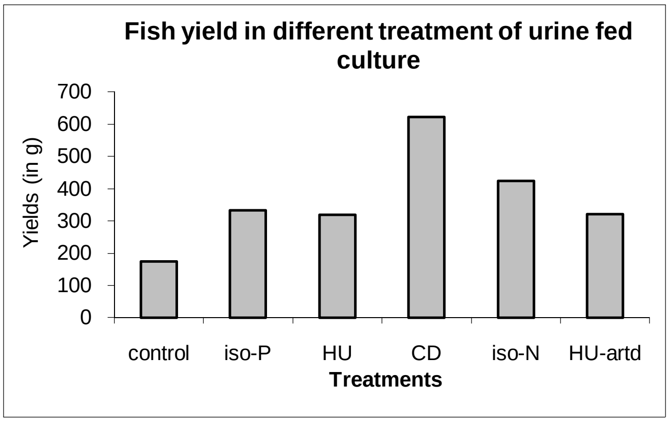

Fig. 7: Variability of total fish yield in different treatments employed (HU: human urine, CD: cattle dung, HD-artd: aerated tanks with human urine – see Table 1 and 2).

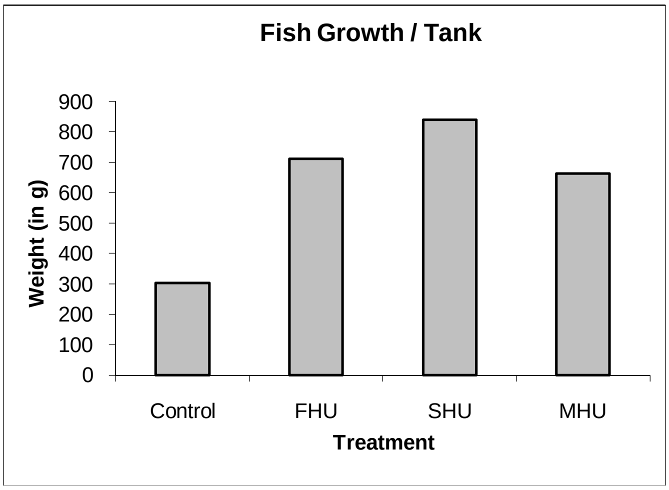

Fig. 8: Responses of fish yield to different urine-fed treatment (FHU: fresh human urine, SHU: stored human urine, MHU: mixed human urine), see Table 1 and 2.

Fig. 9: Netting operation for recording fish growth.

8 Further project components

Further research is required to investigate any pathogenic microbial hazards to human beings and the health impact on fish due to antibiotics, pharmaceutical drugs and other hormonal residues that may be present in human urine especially from people receiving medical treatment.

Such research should be conducted at the farmers' level. NGOs and stakeholders should also be involved in raising awareness among the public and consumers by highlighting the underlying scientific principles of urine based fish culture and the existing apathy for consumption of fish raised in urine fed ponds.

9 Costs and economics

A detailed cost-benefit analysis was not carried out at the farmers' level. A very basic cost-benefit analysis was based on per tank unit. The costs involved are fish, labour and manure/urine, and the profits are calculated on the basis of market price of harvested fish from each tank.

The pilot study showed that profit was the highest under iso-nitrogenous condition, being EUR 0.5 per tank after a total growth period of 4 months. When this figure is extrapolated to hectare basis, the calculated profit is around EUR°1200 per hectare per 4 months culture. The second highest profit was achieved by iso-phosphorus condition (EUR 0.4 per tank). Net profit was not different between aerated (EUR 0.4 per tank) and urine-fed (EUR 0.4 per tank) treatments[3].

However, if only the input cost of fertiliser is considered, the net profit was 27% higher for the cattle dung treatment (EUR 0.6 per tank) than the best net profit (EUR 0.4 per tank) found among the urine-fed treatments.

Also, there is a high risk of environmental eutrophication from the regular application of cattle manure at this dosage, requiring chemical intensive treatment for control. Considering environmental economics and aesthetic view as well, it can be postulated that the use of human urine is cost effective, that it can protect the environment and can support employment opportunities.

10 Operation and maintenance

The operation and maintenance of the culture units was not within the scope of these tests.

11 Practical experience and lessons learnt

This practice may be communicated to the farmers level by organising regular workshops and demonstration camps. The study used eighteen small holding tanks (3 x 1.5 x 1 m, totalling 4500 L) and therefore may suffer from some limitations of ecological conditions of earthen fish ponds and small space for carp growth. However, many farmers do use small holding tanks for short term production of fingerlings for economical reasons. The results are encouraging and may be adopted in homestead ponds.

Social aspects are very important for the acceptance of human urine as fertiliser. The social structure should be

3 The duration of culture in small holding tanks was for 4 months, which was exclusively for the production of carp fingerlings in small tanks. That is why the cost benefit analysis was calculated for a period of 4 months.

motivated to accept the fish grown in urine-fed ponds. Environmental awareness programme is therefore necessary.

12 Sustainability assessment and long-term impacts

A basic assessment (Table 1) was carried out to indicate in which of the five sustainability criteria for sanitation (according to the SuSanA Vision Document 1) this project has its strengths and which aspects were not emphasised (weaknesses).

Table 3: Qualitative indication of sustainability of system. A cross in the respective column shows assessment of the relative sustainability of project (+ means: strong point of project; o means: average strength for this aspect and – means: no emphasis on this aspect for this project).

	collection and transport			treatment			transport and reuse		
Sustainability criteria	+	o	-	+	o	-	+	o	-
• health and hygiene	X			X				X	
• environmental and natural resources	X			X			X		
• technology and operation	X			X			X		
• finance and economics		X			X			X	
• socio-cultural and institutional		X			X			X	

Sustainability criteria for sanitation:

Health and hygiene include the risk of exposure to pathogens and hazardous substances and improvement of livelihood achieved by the application of a certain sanitation system.

Environment and natural resources involve the resources needed in the project as well as the degree of recycling and reuse practiced and the effects of these.

Technology and operation relate to the functionality and ease of constructing, operating and monitoring the entire system as well as its robustness and adaptability to existing systems.

Financial and economic issues include the capacity of households and communities to cover the costs for sanitation as well as the benefit, e.g. from fertilizer and the external impact on the economy.

Socio-cultural and institutional aspects refer to the socio-cultural acceptance and appropriateness of the system, perceptions, gender issues and compliance with legal and institutional frameworks.

For details on these criteria, please see the SuSanA Vision document "Towards more sustainable solutions" (www.susana.org).

Using the five sustainability criteria for sanitation, this project has considerable strengths at the level of resource use, economics and technical operation, but there are limitations of qualitative assurances of the produce due to lack of adequate data on health and hygienic aspects of fish raised on urine-fed system.

The long-term impacts of this approach were not studied in this research project but it can be postulated that:

- By extending this practice to local farmers, it may be possible to raise income levels of rural people and generate employment opportunities through self help groups and establishing linkages with stakeholders for opening an outlet for the sale of urine for live food production such as zooplankton, algae etc.
- This approach may lead to employment generation and sustainable development in the long run.

13 Available documents and references

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14 Institutions, organisations and contact persons

Professor (Dr.) B. B. Jana, Vice Chairman, International Centre for Ecological Engineering, University of Kalyani, Kalyani -741235, West Bengal, India
E-mail: bbj_icee@yahoo.co.in

Case study of SuSanA projects

Reuse of human urine in aquaculture, Kalyani, West Bengal, India

SuSanA 2010

Authors: Prof. B. B. Jana (International Center of Ecological Engineering)

Editing and reviewing: Patrick Bracken (pocb123@yahoo.com), Elisabeth v. Münch, Alemayehu Zewdie Asrat (GTZ ecosan programme - ecosan@gtz.de)