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Use of night soil in agriculture and fish farming

The use of untreated night soil as a fertilizer in agriculture or as a source of nutrients in fish farming presents a considerable health hazard in the form of pathogens and parasites. A pilot study is reported in which night soil was placed in an anaerobic digester, producing biogas and residual organic matter. The latter was introduced into biostabilization ponds, and nutrients were thus obtained for the rearing of fish. Fish ponds receiving nutrients derived from treated night soil were less contaminated than ones to which untreated night soil was applied, and the fish reared in them were of superior quality.

In China some 0.3 million tonnes of night soil are produced every day by 200 million people in more than 450 cities lacking treatment facilities. From most cities, untreated night soil and sewage are transported to rural areas where they are used as fertilizer in agriculture or as food for fish, especially in the south of the country. Unfortunately, a frequent consequence is that pathogens and the eggs of parasites come into contact with workers and farmers. During the 1980s the prevalence of ascariasis, ancylostomiasis and trichuriasis among vegetable farmers reached 94%, 65% and 93% respectively. Contamination affects the soil, ground and surface water, vegetables and fish. Outbreaks of waterborne diseases have frequently occurred among the general public and certain occupational groups because of poor domestic water supplies and the consumption of polluted produce. Thus, early in 1988, hepatitis A struck approximately two million people in Shanghai who had eaten shellfish contaminated with night soil.

We studied levels of contamination in the environment and the routes of pathogen transmission from night soil to humans. An analysis was made of the health risk to sanitarians, piscicultural workers and farmers, and to members of the general population consuming raw fish taken from ponds fertilized with night soil.

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Agriculture

Ascaris eggs and hookworm larvae were much less abundant in soil fertilized with treated night soil than in that fertilized with untreated night soil. The prevalence of parasite eggs in the latter was significantly higher than that in control soil.

Biogas generated by night soil digestion can be used for heating night soil that is to be treated.

Only a few parasite eggs survived on the edible parts of vegetables such as tomato, cucumber, green pepper and green beans grown in soil fertilized with untreated night soil, but some eggs were found on spinach, Chinese cabbage, potherb mustard, scallion, rape, celery and Chinese chives grown in such soil. The number of eggs found depended on the distance between the edible parts and the ground.

Fly population densities in areas where treated night soil had been used were 62% lower on average than in areas where untreated night soil had been applied.

The levels of ground-water turbidity, iron, ammonia and nitrite exceeded acceptable values by 30%, 90%, 50% and 100%, respectively, in rice fields that had been irrigated with untreated domestic wastewater. The most pronounced ground-water pollution by domestic wastewater irrigation consisted of an increase in the total bacterial count. The highest values were greater than the acceptable standard in nine out of ten samples.

The prevalences of parasitoses among agricultural populations in areas of Dalian and Henan where untreated night soil was used were 93% and 55%, respectively; the corresponding figures in areas where treated night soil was used were 70% and 28%.

Aquaculture

Up to 10 000 parasite eggs per 100 ml or 100 g of pond water and sludge were found where ponds had been fertilized with raw night soil. The eggs were mainly in sediment rather than in water. Faecal coliforms were more abundant in water and sludge of ponds where raw night soil had been applied than in controls; in neither case was *Salmonella* detected.

More *Ascaris* and hookworm eggs and *Clonorchis* larvae were detected in the digestive tract contents, gills and flesh of fish fed with raw night soil than in those of fish that had not been given night soil. *Pseudorasbora parva* and grass carp are intermediate hosts for *Clonorchis* and transmission can occur when fish are eaten raw or undercooked and cysts hatch in the human gut. More than 2400 faecal coliforms per 100 g of gills and digestive tract contents were detected where faecal coliform concentrations in pond water exceeded 16 000 per 100 ml.

Parasite eggs may be deposited on edible aquatic plants, and transmission may occur if the fruits are eaten uncooked. Edible plants cultivated in ponds fertilized with excreta may present a health risk to consumers. Even after two rinses, faecal coliforms may still occur on plant surfaces.

Among people eating raw or undercooked fish the *Clonorchis sinensis* infection rate reached 100% in some areas. This was particularly true in Guangdong Province,

where the cultural preference is to consume raw fish grown in ponds to which night soil had been applied.

Among pond workers exposed to untreated night soil, infection rates of ascariasis, trichuriasis, clonorchiasis, fasciolopsiasis and schistosomiasis were higher than among controls. The prevalence of helminth parasites, *Salmonella* and hepatitis B surface antigen in sanitary workers exposed to night soil and wastewater were higher than those in waterworks staff.

Pilot study on treatment of night soil

The *Clonorchis* infection rate was 70% among populations in the provinces of Guangdong, Guangxi, Fujiang, Sichuan, Jiangxi and Jiangshu, where there is a preference for eating uncooked or undercooked fish. In order to minimize health risks the treatment of night soil applied to fish ponds is desirable. Anaerobic digestion is widely employed for this purpose. The bio-stabilization pond technology, notable for low cost, low energy consumption and simplicity in operation and maintenance, is mostly used for wastewater treatment. A pilot study was conducted with a view to combining these two technologies. Demonstration facilities were installed in Jiujiang City, Jiangxi Province.

A pretreatment tank, consisting of a screen and a trap, was used for removing silt and floating materials, which usually account for 0.03% and 1.5% respectively of the night soil collected from latrines. The night soil was heated to 55 °C for one hour in a tank so as to destroy some pathogens and provide heat for an anaerobic digester in which organic matter was partly converted to biogas and where parasite eggs and some pathogenic bacteria were inactivated over a ten-day period. In a series of three ponds the residual organic matter was introduced into the food chain. After the anaerobic and facultative processes in the first two ponds the effluent was delivered directly to the fish ponds to provide supplementary nutrients. There was sufficient dissolved oxygen and food in the third stabilization pond to allow the rearing of fish.

The study was conducted in a fishery with a 270 000-m^2 stocking pond located two kilometres from the centre of Jiujiang City. Night soil collected from public toilets on a daily basis was regularly transported to the site in tank trucks and stored in a 1000-m^3 tank. A boiler house, biogas storage tank, anaerobic digester and biostabilization ponds were provided on the site.

A 99.9% reduction in chemical oxygen demand and biological oxygen demand was achieved; total solids were reduced by at least 80%; faecal coliforms were reduced by up to ten orders of magnitude, parasite eggs were decreased by 99.8%; dissolved nitrates were reduced by 60%; and the effluent from the biostabilization ponds met the water quality standard for aquaculture pH 6.8–7.0, dissolved oxygen >8 mg/l, and biological oxygen demand <30 mg/l.

Nutrients produced through the treatment of night soil can be used to rear fish in biostabilization ponds.

As between fish ponds fertilized with treated and untreated night soil, no significant differences in pH or temperature were observed. However, the dissolved oxygen in the experimental pond water was always higher than that of the control, especially during the hot seasons.

Faecal coliform levels were lower in the experimental ponds than in the control. No *Salmonella* were detected in water from the experimental ponds fertilized with treated night soil or in fish reared in them, but *Salmonella* were found in water from ponds fertilized with untreated night soil and in the digestive tracts of fish obtained in these ponds.

Pathogens and the eggs of parasites are destroyed and a suitable environment for fish growth is established.

The growth rate of fish in ponds with treated night soil was double that in ponds with untreated night soil. Furthermore, fish reared in ponds where treated night soil was used were not susceptible to infectious diseases, and the mortality rate was negligible. The quality of fish harvested from ponds with treated night soil was much better than that where the untreated material was used.

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Numerous pathogens are harboured in untreated night soil and wastewater, the treatment of which has as its prime objective the elimination of this hazard. Treatment helps to solve pollution problems and minimize health risks associated with the use of these materials in agriculture and aquaculture. More attention should be given to the systematic management of the use of night soil, with reference to policy development, legislation, standards and health education.

The pilot study demonstrated the following advantages of the reported night soil treatment technology.

- Biogas generated by night soil digestion can be used for heating night soil that is to be treated.
- Nutrients produced through the treatment of night soil can be used to rear fish in biostabilization ponds.
- Pathogens and the eggs of parasites are destroyed and a suitable environment for fish growth is established.

The technology thus produces significant health and economic gains as well as environmental benefits. □

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