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SHEDDING LIGHT ON NIGHTSOIL: THE NIGHTSOIL MANAGEMENT IMPROVEMENT STUDY IN HUBEI, CHINA

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In many major cities in China and elsewhere in Asia, human waste is disposed of through a system of nightsoil collection from bucket latrines, conservancy tanks, and septic tanks. The waste is then transported by carts, tanker trucks and barges to agricultural land where it is applied, often without treatment, and is valued as a fertilizer and soil conditioner. This practice constitutes a major health hazard to farmers and to the workers who manage the waste. A study linked to the World Bank-financed Hubei Urban Environment Project, executed by the UNDP/World Bank Water & Sanitation program in collaboration with the Swiss-financed Sanitation for Developing Countries Program (SANDEC), is assessing nightsoil management practices and developing an integrated strategy for safer management that incorporates health, socio-economic, and engineering considerations.

The Hubei Urban Environment Project:

The Hubei Urban Environment Project (HUEP) is one of a series of environmental projects for China that are partially financed by the World Bank. The project is being implemented in the cities of Wuhan, Huangshi, Xiangfan, and Yichang in central Hubei Province. The four cities have a combined population of 4.5 million people, with the largest, Wuhan, comprising 3.2 million inhabitants. The project focuses on provision of municipal environmental management services, including sewerage and sanitation improvements, nightsoil and solid waste management, and industrial pollution control.

One component of HUEP aims at improving areas with inadequate sanitation facilities and the unhygienic management and use of human excreta and urine, collectively termed "nightsoil". It is estimated that 30 to 60% of the population in the project cities do not have access to sewerage and rely on septic tanks or pit latrines, and in peri-urban areas over 70% of the households use pit latrines. Most of the nightsoil from these facilities is collected by the Sanitation Bureaus of the each city, and it is estimated that a combined total of 6,000 to 8,000 tons of nightsoil is produced daily.

Prevailing Nightsoil Management Practices:

Nightsoil has traditionally been used for cultivation in China, especially of fruits and vegetables. The tradition

continues today, especially on the periphery of cities, but the demand for nightsoil seems to be decreasing because of the increasing availability of subsidized chemical fertilizers, changing farming patterns, and reduced agricultural land in the urban periphery. Nonetheless, many farmers feel that "vegetables taste better when grown with nightsoil rather than chemical fertilizer", and the demand for vegetables and other food crops will grow significantly in the coming years due to the rapid growth of urban areas.

At the same time, the supply of nightsoil is decreasing as public and private water flushed toilets are connected to sewer systems. It seems that the reduction in the supply is more rapid than the reduction in demand, resulting in pressure to forego the treatment stage in nightsoil management and deliver raw septage directly to farmers.

The existing nightsoil management system generally consists of collection of septage and dry latrine nightsoil by the Sanitation Bureaus of each city, retention in storage containers, or less often discharging into sewers. The wastes, sometimes treated but more often not, are either collected by individual farmers or transported for a fee by the Sanitation Bureaus to fields to be used as fertilizer.

Sludge from septic tanks and fresh nightsoil from dry latrines are often used without any treatment. Although health statistics are very limited at this point, this arrangement implies a considerable health hazard. In particular, nightsoil workers (of whom the large majority

are women), farmers, and children would seem to be at risk. The major problems in the non-sewered areas have been identified as:

- improper septic tank designs, and lack of adherence to existing building regulations;
- irregular emptying and therefore overloading of the septic tanks;
- inadequate treatment of septage due to inappropriate storage tank designs;
- general pollution of non-sewered areas from septic tank overflows.

The Nightsoil Management Study:

The Nightsoil Management Improvement Study is a learning opportunity that will have significance for other environmental sanitation projects in China and elsewhere (i.e. Vietnam). It has also directly influenced the design and implementation of HUEP. It examines the key inter-related aspects of: hygiene and epidemiology of the existing methods for handling nightsoil, socio-economic and marketing aspects of its management and use, and technical options for improved management, and finally the costs and benefits of alternative practices.

The study is linked to a series of demonstration activities that include construction and monitoring of modified septic tanks for both public and private latrines, monitoring of existing septic tanks, construction and monitoring of modified nightsoil storage tanks, and establishing a pilot plant for co-composting nightsoil and solid waste. The outcomes of these demonstration activities will provide input to the final design and implementation of HUEP.

Hygiene and Epidemiological Findings:

The findings of the hygiene education study indicate a weak hygiene education program and limited practice of safe hygiene behavior. People in the study area have some knowledge of the relationship between good sanitation practices and disease prevention, but it was not fully understood, and key behaviors were not well practiced. Sanitation facilities were not adequate and there was a demand from users for improvements. The continued demand for nightsoil in the peri-urban areas means that improvements in physical facilities and sanitation service will have to take this demand into account.

The epidemiological study looked at existing disease morbidity/mortality data from the project cities and other urban areas in China. It also carried out case studies of dysentery and hepatitis morbidity and a cross-sectional survey of helminth infections among farmers. Some of the findings include the following:

- *Hygiene Behavior.* The lack of hand washing, particularly after defecation, before cooking and eating posed significant health risks to people. If the behavior was analyzed by occupation, groups that were directly exposed to nightsoil, like farmers and fishermen, demonstrated a 3 times higher chance of getting hepatitis than was found for the rest of the study population.

- *Food Hygiene and Consumption.* Unsafe practices in food hygiene and consumption habits indicated significant health risks for the population, particularly as related to hepatitis and dysentery. The danger in eating leftovers and food that was left uncovered could be attributed to unsafe food storage practices, particularly during warm summer months. Drinking unboiled water and buying vegetables from open markets were also risky. The consumption of raw vegetables increased the risk of contracting dysentery 1.8 times. For farmers, consuming unboiled drinking water increased the risk 3.5-fold.

- *Environment.* Hepatitis and dysentery cases reported problems with flies in their household significantly more often than controls. Also, children under the age of 13 years were found to have a higher hepatitis infection risk if they played near ponds, garbage heaps, and vegetable gardens; these were areas that were more likely to be contaminated with nightsoil.

- *Hygiene Education.* A striking result of the risk factor assessment indicated that the lack of exposure to health and hygiene education during schooling was associated with highly significant 5.6 times for contracting hepatitis A and 7 times for dysentery. The respondents in the case study group had less exposure to hygiene education than the healthy control group.

- *Helminth infections.* Specific health risks were found for population groups that are occupationally exposed to nightsoil. There was a considerably higher infection rate among nightsoil using communities in all age groups compared to non-users, but the prevalence of infection was significantly higher in the age strata 31 - 60 years that represents the majority of people working in the fields. In all communities, helminth infections occurred significantly more often among children below 10 years of age (35% infection rate).

In summary, the findings of the epidemiological study show a high prevalence of enteric-related diseases, similar to other studies in similar Chinese cities. Statistical analysis provided clear correlation between several key factors--such as, the lack of proper hygiene behavior, unsafe food hygiene practices, and environmental risk factors--and the increased risk of contracting excreta-related diseases. Lack of exposure to hygiene education in school showed a highly significant correlation.

The high risk groups who stood a greater chance of contracting diseases were: a) farmers, who were significantly less exposed to health education and more exposed to untreated nightsoil handling; b) sanitary workers; and c) young children under 10 years old.

Economic and Marketing Aspects:

In the first phase of this study, an overall assessment was made of the economic and marketing aspects of nightsoil use in each project city. The main trend is that of a marked reduction in nightsoil sales since 1992. This is in contrast to rapid growth in sales immediately prior to this period. The cities' program for conversion from dry to wet latrines accelerated over the same period. These conversions resulted in a change in the quality of nightsoil as perceived by farmers; that the available nightsoil is wet material which has several disadvantages from their point of view. These disadvantages are:

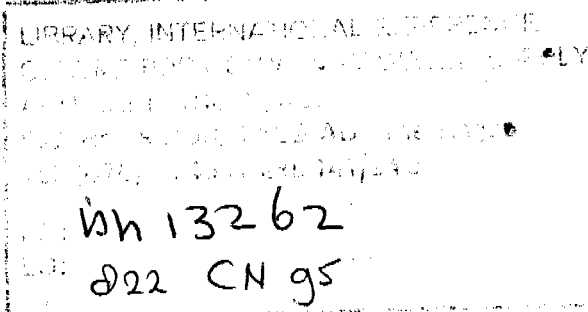
- It is viewed as being less nutritious to plants.
- It is heavy, difficult to transport and requires a larger investment in storage facilities at the farm.
- Its wetness means that most farmers do not have suitable transportation of their own. Moreover, the city has only four vehicles with a total of 16 tons of carrying capacity. The constancy of sales by city truck appears to be at least in part due to the constraint imposed by transport.
- It is claimed that wet material has more foreign bodies, e.g. plastic and paper.
- Control of the dilution is under farmer control for the dry material but not the available wet material.

Nevertheless it was found that nightsoil is still sold to farmers, indicating a potential for market sales, but the change in the perceived quality of nightsoil consequent upon the conversion to wet latrines has reduced demand for the product. The possibility for full cost recovery of station operating costs is not high. Nevertheless improved cost

recovery could be achieved through a mixture of increasing revenue and reducing costs. It is important to realize that the latter is a potentially powerful component of cost recovery. Also, it should be recognized that in the absence of finding an adequate market outlet for nightsoil, the authorities will still have to bear the costs of safely disposing of this material.

The market survey results provide a number of clear findings regarding the use of nightsoil in vegetable farming in the suburban areas in the two project cities. The main conclusions to be drawn from the results of the farmer surveys are:

- there is preference to continue to use nightsoil but the nightsoil should be "dry" and not "wet";
- there is a strong preference to use nightsoil even though chemical fertilizers are also used;
- there has been a reduction in supply of nightsoil by city authorities, thereby reducing the availability of nightsoil;
- main characteristics sought by farmers in nightsoil (apart from nutritional value) are low cost, ease of transport and delivery to farm;
- amount spent on nightsoil per year is around RMB 600 per farmer for nightsoil and RMB 1,100 for chemical fertilizer;
- both nightsoil and chemical fertilizers are used throughout the year with a peak season in spring (March) and a low season in winter (January);
- there is a high willingness to pay for nightsoil, but this is only for good "fresh" nightsoil (up to RMB 21 per ton) or treated nightsoil (up to RMB 25 per ton). For nightsoil and solid waste co-compost willingness is higher - at RMB 50 to 55 per ton;
- there is a lack of good sources of information for both nightsoil and chemical fertilizer; and
- among the main requirements suggested by farmers to improve the nightsoil operations are for the City Sanitation Department to provide good and inexpensive nightsoil, including transport facilities.



Technical Pilot Activities:

The demonstration part of the Study consists of several technical pilot activities which are currently being undertaken in three cities. The activities are being undertaken by the Sanitation Department in each city with technical advice from RWSGEAP and SANDEC. The activities include: construction and monitoring of modified septic tanks in both private and public latrines; monitoring of existing septic tanks for comparative purposes; construction and monitoring of modified nightsoil storage tanks; and setting up a pilot plant for co-composting of nightsoil and solid waste. The pilot activities will be carefully monitored (through 1995) and refinements made; the information and improved capacity to undertake such activities will provide input to HUEP.

The objectives of the pilot and demonstration activities are to evaluate the treatment efficiency of properly designed and operated conventional Chinese septic tanks and to test the potential for improving the treatment efficiency of septic tanks through innovative and low cost modifications in their design and operation. The modified systems include the anaerobic baffled reactor (tested in Huangshi) and the anaerobic filter (tested in Yichang). These two systems have the advantage over conventional septic tanks in that there is much better contact between the fine and dissolved organic matter in the wastewater and the anaerobic bacteria. Therefore, a much higher efficiency with regard to the removal of BOD can be expected compared to conventional septic tanks.

The purpose of the nightsoil storage tank activity is to attempt to provide some treatment to the nightsoil to reduce the pathogen content as well as provide a more useful fertilizer by obtaining a better digested nightsoil. The improved tanks are designed to provide easier access and loading of the semi treated nightsoil by farmers at the tank outlet.

Co-composting of nightsoil and solid waste has never been tried in any of the project cities. If this process can be shown to be technically feasible, it will have significant benefits in providing a combined treatment option for both nightsoil and solid waste and earning income from the sale of compost to farmers. This activity will try a small capacity treatment plant based on the aerated pile method for composting.

Recommendations:

The review of the health data and findings from the various study components--hygiene, epidemiology, market analysis

and technical pilot activities--clearly identified the need for a coordinated approach based on technical improvements, better management practices, better information and education in the sanitation aspects of nightsoil and related aspects for the improvement of the health and welfare of the people in the project cities. Improvements are recommended in the following areas:

1. Improvements in sanitation physical facilities
2. Improvements in sanitation service, including the treatment of nightsoil
3. Promotion of better hygiene practices through an improved hygiene and sanitation promotion program
4. Improvements in the management of nightsoil
5. Other identified areas, including privatization

Improvements in physical facilities will require parallel improvements in nightsoil management and, for maximum health impact, these will require improvements in related hygiene behaviors through an improved hygiene education program. Provincial and city health authorities need to develop an appropriate and effective hygiene education program, especially for the identified high risk groups such as farmers, nightsoil workers, young children and consumers living in unsafe areas.

The recommendations proposed here have taken into account the findings from the four integrated studies as a whole. Which agency will undertake what part of the recommended activities will be up to the municipalities themselves. However, these recommendations have been proposed with maximum health benefits in mind. The items to be included in the final investment program under HUEP will be based on environmental considerations and on discussions between the cities and the World Bank.

The nightsoil management improvement program is part of the larger **Sewerage and Sanitation Improvement Component** of HUEP which looks at investments in trunk and secondary sewer systems, pumping facilities and wastewater treatment facilities in the four project cities. An urban sewerage and sanitation strategy for the project cities needs to have long-term planning and staged development over a period over a number of years, e.g., 15 to 20 years for reasons of limited financial resources, economic development and changes due population growth. While trunk and some secondary sewers can be constructed for city centers in HUEP, many of the older inner core of the city and peripheral areas will not be covered immediately.

The development of these areas will have to be phased over a period of several years. However, in the immediate and intermediate future, improvements to the current situation, including alternative low cost technologies, will be required.

The recommendations put forth in the nightsoil management improvement study report complements the improvements proposed by the sewerage and sanitation component and provides services to a needy and unserved part of the population. Present proposals for sewerage improvements under the HUEP project will provide improvements mainly to trunk and main lines. Funds within the HUEP project will not be sufficient to cover construction and installation of tertiary distributions, house connections, and full treatment facilities. Even with the large investments to be provided under this project, it is anticipated that a significant proportion of the urban residents will not be able to have complete sewerage facilities. With the anticipated growth and development in the cities, unless additional funding is provided, many residents will remain without adequate sanitation facilities. Proposals included in the nightsoil component are intended to provide additional improvements not only to assist the nightsoil and septic tank sludge use in agriculture and aquaculture, but to provide improvements in areas which are not covered under the sewerage improvements, which in the main are in the low income and poorer areas of the city.

1. Improvements in Sanitation Facilities:

Conclusion: Existing sanitation coverage is still inadequate in many areas. Many areas are not served by sewerage systems and may not be covered in future proposals by the cities. Numerous residents, particularly in those living in older buildings, do not have private facilities and rely on public latrines. In other areas, where buildings do have private latrine facilities, not all have adequate discharge outlets either to sewerage or reasonable drainage system, resulting in unsanitary conditions around buildings. In the peri-urban farming areas, there is a lack of water supply and sanitation facilities. It has been observed that some school sanitation facilities also need improvement.

Septic tanks are the main form of primary treatment for wastewater discharges from buildings and households. But septic tanks often do not function properly due to overloading, inadequate maintenance and improper poor design and construction.

In all project cities nightsoil storage tanks were constructed to be used as a transfer point for nightsoil collection from both public latrines and septic tank de-sludging operations;

farmers could then obtain nightsoil to be used as fertilizer. However most of these tanks are not operational due to a number of reasons, including improper design and inconvenient locations for the farming community. Nightsoil and septic tank sludge is often collected by farmers in a fresh state with a high risk of contamination by pathogens and coliform.

From the field investigations it has been found that the public generally is willing to pay to use public latrines, but with proper facilities of running water and flush latrines.

Recommendations: Improvements are required to the sanitation facilities both to increase access to adequate sanitation services as well as to improve the nightsoil operations for agricultural uses. Increasing access to sanitation facilities would require the provision of new facilities as well as improving the design and construction of the existing facilities, such as:

- conversion of dry to water flush public latrines;
- improved septic tank designs;
- provision of equipment for septic tank de-sludging;
- construction of more efficient septic tanks to serve several buildings in specific local areas; and
- investigation of lower cost sewers to assess their suitability in the project cities.

Improvements to the collection, transport, storage and distribution of nightsoil and septic tank sludge for use as fertilizer in agriculture would require the following:

- improved nightsoil storage tank design and location;
- more vehicle resources for transport of nightsoil; and
- provide treatment to the nightsoil used for fertilizer to reduce harmful pathogens.

From the market survey results, most vegetable farmers interviewed stated that they are now using less nightsoil than before. The reasons given included a reduction in the supply of nightsoil by the city authorities and lack of transport facilities. However they would still prefer to use nightsoil (in many cases in preference to chemical fertilizer) if there was sufficient amount of available nightsoil and a more convenient arrangement for collection and transport of nightsoil.

Improved water supply and sanitation facilities for people living in the peri-urban areas are required, especially where there are farms growing food for the city center. The improvements should take into account farmers' need for nightsoil in cultivation. This could mean improved and safe designs for dry latrines and treatment options.

Improvements in these facilities would greatly benefit the women in providing them easy access to safe facilities and decrease their time in having to care for sick children and other members of the household.

The technical pilot activities will test a number of septic tanks, storage tanks and nightsoil treatment designs, which can be applied to provide some of the technical improvements to a number of these facilities in the proposed project implementation program.

2. Improvements in Sanitation Service:

Conclusion: As discussed in the previous section A, there is inadequate service coverage for sanitation in the project cities. In addition, existing servicing of septic tank cleaning is irregular or, at times, not at all. The cities do not have adequate resources for maintenance of their vehicles and equipment. There are very few means of treating nightsoil before the nightsoil or septic tank sludge is collected by farmers. Existing controls on waste disposal do not appear to be implemented well. The cities do not have sufficient resources to provide adequate septic tank de-sludging services.

Recommendations: The study recommends that increasing the service coverage, particularly in the areas without sewerage and reticulated drainage, can be achieved by the provision of a number of facilities, and in addition with the following service improvements:

- improvement to the maintenance and cleaning of septic tanks for both public latrines as well individual buildings;
- use of more efficient septic tanks to serve areas without sewerage or drainage facilities;
- improvement to maintenance of service vehicles for collection of nightsoil;
- better and more systematic control on polluting wastewater discharges.
- stricter control on septic tank design and operation at buildings and public latrines;

- construction of more public latrines;
- more sanitary disposal of nightsoil; and
- develop more efficient and workable methods of disposal of wastes and effluents, including co-composting, possibility of collection and utilization of waste gases, safe means of storing nightsoil and septic sludge.

3. Improvements in Hygiene and Sanitation Promotion:

Conclusion: Findings from the hygiene study indicate a weak hygiene education program and limited practice of proper sanitary behavior. People had some knowledge of the relationship between proper hygiene behavior and disease prevention but it was not fully understood and key behaviors were not well practiced. Statistical analysis from the epidemiological study provided clear correlation between several key factors including the lack of proper hygiene behavior, unsafe food hygiene practices, environmental risk factors, and nightsoil handling, and the increased risk of contracting excreta-related diseases. Lack of exposure to hygiene education in school showed a highly significant correlation with health risks.

Recommendations: The study strongly recommends improvements in the hygiene education program for the project cities and their environs as well as continuous health impact assessment to provide continuous feedback into the hygiene education program as well as other sanitation improvements.

The city health authorities together with the sanitation bureaus should develop an appropriate and effective Hygiene and Sanitation Promotion Program focusing on **improving key sanitary behaviors while improving latrine facilities** for high risk populations. Certain population groups and the schools, particularly primary schools, should be the main targets for the program. The main objective of a sanitation promotion program is to improve human health. It should include the dual component of providing hygienic latrines for the safe deposit of excreta and hygiene promotion. Hygiene promotion would be focused on three key sanitary behaviors which interrupt disease transmission. Techniques for hygiene promotion will involve the participation of the community as much as possible. Appropriate channels of communication will be identified, such as community venues, schools, work units, local health posts, radio, TV, and printed material.

In addition and as support to the above interventions, there should be a **Monitoring and Evaluation Component** of the health impact of the proposed improvement activities in all four project cities to: (I) assess the effectiveness of the proposed nightsoil management improvements; and (ii) validate the program's health outcome. This could be accomplished by:

- continuous monitoring of selected infectious disease morbidity as well as behavioral changes through the existing district and village/community-based routine operations; and
- conducting one case-control study in each city in selected high risk areas covered by the nightsoil management improvement interventions and within selected population strata.

Monitoring and evaluation activities can be initiated after the hygiene and sanitation promotion interventions have been in place and after a major portion of other nightsoil management improvements have been implemented.

4. Improvements in Nightsoil Management:

Conclusion: There is inadequate management of the nightsoil and sanitation facilities; the main aspects noted in this study are:

- revenue from public latrines and septic tank desludging operations does not appear to be fully recovered;
- there is inadequate and irregular surveillance and monitoring of revenue collection;
- there is lack of supervision (and education) for sanitary units in hygienic work methods; and
- insufficient allocation of sufficient resources (plus vehicles/equipment) with a need for a need for better and more convenient nightsoil supply for farmers, including transport of nightsoil.

The market survey carried out of farmers in Wuhan and Huangshi has found that farmers are willing to pay for treated nightsoil and composted nightsoil. This factor suggests that there is potential for revenue and income generation to the cities by provision of improved and better service of nightsoil supply.

The market survey also found that vegetable farmers in the peri-urban areas of the cities recognize the need to use treated (rather than fresh nightsoil) to reduce the harmful pathogen content; it also found that lack of facilities for transport of nightsoil is a problem. There is a need for the

city authorities to improve the treatment (such as in nightsoil storage tanks, additional treatment facilities) and the supply of nightsoil to the peripheral farming areas of the city.

Recommendations: Management and operation of a number of aspects of sanitation facilities, nightsoil operations, revenue and income management, could be improved in the project cities to provide a more efficient service and improve the sanitation and hygiene situation in the urban residential as well as peri-urban farming areas. Specific recommended improvements include:

- more efficient and effective administration and management of septic tank cleaning, which will require rigorous enforcement of existing legislation controlling septage dumping;
- improve collection, treatment, and sale of nightsoil;
- more regular surveillance and monitoring of nightsoil operations, latrine use, and septic tank operations;
- improve supervision (and education) for sanitary units
- allocation of sufficient resources (plus vehicles/equipment) will need to be supported by a well managed vehicle servicing operation; and
- improve collection of user fees and revenues from public latrines, sale of nightsoil, and septic tank cleaning.

5. Improvements in Other Areas/Services:

Conclusion: The study findings also indicated several additional areas for improvement. These include:

- with the cities' limited resources there is potential for privatization of several of the operations, including septic tank cleaning, and transport of nightsoil (perhaps similar to privatization of solid waste collection and transport);
- in view of the prevalent use of nightsoil as a fertilizer for vegetable growing, the sale of vegetables bought at markets may contain harmful pathogens from nightsoil application; and
- there is an unaccounted for "floating" (non-registered) population which would add another 10 to 20% to the urban core of cities; these people rely on public latrines for all their sanitary needs.

Recommendations: Recommendations by the study team are:

- Privatization of septic tank cleaning operations should be considered as a viable option to supplement the cities' sanitation service. This should be in the form of a public service supported by adequate (and improved) controls and regulations on septic tank construction, operation, as well as on unauthorized and unsanitary discharge of wastes from buildings and public latrines. Privatization could be considered for transport and collection of septic tank sludge (this is a common practice in other countries) as well the possibility of treating the nightsoil and sludge on a commercial basis.
- Controls for the sale and public handling of food should be strengthened and/or implemented more rigorously particularly for the products derived from nightsoil fertilization.

- While improving public facilities would benefit the non-registered population, there is also a need for a sewerage/sanitation plan to anticipate even larger influx of the floating population due to the disruption and resettlement of over 1 million people around the Three Gorges Dam; especially in Yichang and Wuhan.

Further Reading:

China: Nightsoil Management Improvement Study in Hubei, UNDP/World Bank Water & Sanitation Program, July, 1995

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