Nam Dinh – Planning for Improved Faecal Sludge Management and Treatment [1]

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Abstract

The authors describe the objectives, approach and results of a planning study undertaken in Nam Dinh to improve faecal sludge management. Sludges collected from on-site sanitation systems are still discharged untreated into drains and watercourses or used untreated in agriculture and aquaculture. Health hazards and clogging of drains are the major consequences. Septic tanks are the predominant form of sanitary installation, today already and even more so in future. The Study proposes two strategic options to enhance septage collection rates and suggests three potentially feasible options for treating septage. The options are evaluated as to their treatment performance; operational requirements and safety; land use and cost. All three options allow for the production of hygienically safe biosolids, apt for use in agriculture.

Key words: Collection; faecal sludge; organic fertilizer; management; septage; treatment

Framework, Rationale and Study Methodology

A planning study for improved FS management and treatment in Nam Dinh was carried out between June and September 2001. It is a component of the Nam Dinh Urban Development Project (NDUDP). This project, in turn, is part of the joint GoV/GoS UDP encompassing the Cities of Nam Dinh, Hué and Dong Hoi. The UDP aim at improving urban drainage and sanitation and strengthening the institutional capacities. The Study was conducted in collaboration with Colenco, a Swiss consulting firm, which is commissioned by GoS to render technical and institutional assistance for the authorities of Nam Dinh.

On-site sanitation installations – septic tanks, unsewered family and public pit or vault toilets and bucket latrines – are the dominant form of sanitation in the majority of towns and cities in Vietnam as well as in other SE Asian countries. Yet, the contents of the pits and vaults in Nam Dinh and other Vietnamese cities, so-called faecal sludges, are either discharged untreated into drainage ditches, natural or man-made surface waters, or on unused land, or used untreated in peri-urban agriculture and aquaculture. This creates health hazards and water pollution and leads to the blockage of drainage systems. This last impact is particularly important in Nam Dinh, which is located in the Red River delta and where drains have very low gradients. There is, worldwide, a lack of options for the treatment of FS, which may be considered appropriate for economically less developed countries. The authors, in collaboration with partners in several countries of Asia, Africa and Latin America, have been conducting extensive field research to develop such options over several years.

The Planning Study aimed at having at hand a basic strategy for improving FS management and an array of appropriate FS treatment options. The new strategy and an FS treatment scheme once selected by the City and made operational, will contribute to reducing the spreading of excreted pathogens and of pollutants within the city environment. The Study encompassed the following sequential activities:

- Assessing the existing sanitation infrastructure, trends and associated risks
- Assessing the current FS management practice + its shortcomings
- Identifying and interviewing the stakeholders
- Defining the goals and paradigms of future FS management
- Pre-selecting management + treatment options which appear appropriate for Nam Dinh
- Description, preliminary design, and costing of three selected treatment options
- Establishing a multi-criteria evaluation matrix for selecting the preferred treatment option
- Suggesting management and institutional measures

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Acronyms, abbreviations and glossary used:

AIT	Asian Institute of Technology
Biosolids	The solids fraction of faecal sludge or of wastewater treatment plant sludge, which is biochemically stable and hygienically safe and can therefore be used in agriculture as a soil conditioner and fertilizer
BOD	Biochemical oxygen demand
COD	Chemical oxygen demand
CW	Constructed wetlands
EAWAG	Swiss Fed. Inst. of Env. Science & Technology
FC	Faecal coliforms
FS	Faecal sludge
GoS	Government of Switzerland
GoV	Government of Vietnam
MPN	Most probable number
MSW	Municipal solid waste
NDUDP	Nam Dinh Urban Development Project
PUE	Public Utility Entreprise
SANDEC	Dept. of Water & Sanitation in Dev. Countries
SS	Suspended solids
TS	Total solids
UCMC	Urban Construction and Management Company
URENCO	Urban Environmental Company
WWTP	Wastewater treatment plant

Sanitation infrastructure and septage disposal: Current situation, problems and future developments

Sanitation infrastructure

The City of Nam Dinh has a population of 230,000. The sanitation systems in use in 1997, the time when NDUDP was started, were septic tanks (50 %), bucket latrines (21 %), toilets directly connected to sewers (16 %), and pit and dry double-vault latrines (10 %). The traditional systems such as bucket latrines, pit latrines or double vault latrines are currently being replaced in a high pace by pour or cistern-flush toilets connected to a septic tank. The construction of septic tanks is promoted by a credit program of NDUDP as part of a wastewater and drainage strategy, which favours the improvement of the existing sanitation and drainage system over sewered sanitation. It is expected that 85 % of households (equiv. to 40,000 households) will be served by septic tanks by 2005. City-wide, conventional sewerage is deemed unfeasible in the foreseeable future for economic reasons and due to the flat topography, which would call for extensive pumping. However, small-bore sewerage carrying wastewater pre-settled in septic tanks, may become feasible in future for selected, densely built-up city neighbourhoods.

Faecal sludge collection and haulage

Septic tanks are emptied when toilet drains become blocked or when owners are bothered by bad odours, i.e. when the tank has become filled up with solids and has ceased functioning as a solids withholding unit. Some owners have their septic tanks emptied at regular intervals to prevent blockage, but this is rather the exception. The owner mandates either Urenco or private entrepreneurs to empty the septic tank. Urenco avails of one vacuum tanker, with which, in the year 2000, it emptied only 150 septic tanks. Private emptiers evacuate the sludge manually with shovels. It is impossible to assess the number of manually emptied septic tanks as no statistics exist. Approximately one third of the houses are located in narrow lanes, i.e. out of the range of the vacuum tanker. Currently these houses are served by manual emptying, exclusively.

Collectors empty public bucket latrines at daily to weekly intervals, usually at night or in the early morning hours. They are either farmers or microentrepreneurs, who sell the sludge to farmers.

Disposal and use in agriculture and aquaculture

Septage is discharged into fishponds, on fields or wherever the driver of the vacuum tanker finds a location to dump it. Sometimes a small amount of money (10'000 VND per truck) can be obtained from a farmer or pond owner, but generally the effort necessary to find a person willing to take a load of septage is not worth the money.

Bucket sludge is in great demand by farmers and fishermen. Up to 1'000 VND are paid per kg fresh sludge. Farmers state that bucket sludge is becoming increasingly unavailable and expensive, due to the replacement of bucket latrines by septic tanks, both in urban and rural areas. Bucket sludge from the city is usually stored for one to two months on a pile next to the field, together with human waste from the farmer's family, with animal waste and plant residues.

Disease situation

The most common diseases among Nam Dinh's population reported in 1996 were diarrhoea, dysentery, typhoid and influenza. Worm (Ascaris) infections with 92% of school pupils affected constitute another health problem. Most of these diseases are related to poor personal hygiene, poor sanitation and possibly use of untreated excreta in agriculture and aquaculture. Quite likely, the current excreta and wastewater management practice contributes substantially to the endemicity of enteric infections.

Summary of problems, challenges and objectives

The inadequate frequency of septic tank emptying causes considerable carry-over of wastewater solids into the surface drainage system, thereby causing public health risks and silting of drainage canals. As a consequence, canals may not fulfil their function during periods of increased surface runoff. Flooding will then be aggravated. Hence, the intensive use of septic tanks for excreta and wastewater management remains inappropriate unless efforts are undertaken to arrive at increased frequencies of septic tank emptying. Even with better emptying practices, though, non-negligible loads of pathogens are discharged from septic tanks into street drains, drainage ditches and canals via the settled effluent. The frequencies for emptying septic tanks remained low to date because of limited willingness or ability-to-pay of the users. Devising an emptying management based on efficient and cost-effective public or private entrepreneurship is therefore needed. In densely built-up neighbourhoods, septic tanks may often not be accessible due to the narrowness of lanes. Appropriate equipment needs to be procured and put at use to overcome this.

Faecal sludges collected from septic tanks and bucket toilets remained untreated to date. Installing appropriate treatment at adequate capacities and strategically located to minimise haulage distances and allow for easy marketing of treatment products to farmers and fishermen constitutes a further challenge of immediate urgency. Experience has shown that identifying areas for treatment of either liquid or solid waste is difficult due to public resistance from nearby dwellers or from dwellers living along access roads.

Stakeholders interviewed and farmers' demand for organic fertiliser

Considerable time was used in the initial stages of the Study to identify, contact and interview important stakeholders and informants. They are.

- Farmers and fishermen (often the same as many farming families own small domestic fish ponds)
- Farmers' cooperatives
- Provincial Agricultural and Rural Development Service
- Municipal Agriculture Department
- URENCO
- UCMC
- Households

Interviewing farmers and cooperatives yielded the important information that there exists great demand for so-called "organic fertilizer", i.e. finished products from municipal waste treatment such as FS treatment or MSW composting. The supply of faecal sludge is decreasing due to the replacing of bucket latrines by septic tanks and the ineffective collection of septage. There is, reportedly, strong awareness among the farmers that soils require not only mineral fertilizer but also replenishment of organic material. Their willingness to purchase biosolids or compost depends on sales prices and demonstrated effects of applying such material to the soils. Purchasing biosolids or compost through the established coop outlets and sales organisation would be the option preferred by the farmers.

Septage management and treatment options: the basis of planning, pre-selection of options, and option description and costing

Basis of Planning

Planning Horizon and Design Capacity

Given the dynamic developments in the City and the lack or unreliability of statistical data related to sanitation infrastructure, excreta collection, future treatment needs and characteristics of sludges delivered to the future treatment plant, rather short planning horizons have been chosen. The first one (2002/2003) is to cater for needs, which are reasonably well predictable. The second one (2004/2006) will cover needs, the prediction of which is more insecure. Also, experiences to be gained with a treatment plant of limited size may then be utilised in an expanded treatment system design to be prepared for the second stage handling of FS.

It was proposed that the first-stage treatment capacity should cater for 1,000 septic tank emptyings per year, equivalent to 2,500 m^3 of septage. Emptying capacity and actual operations may increase to 2,000 – 7,000 septic tank emptyings per year by 2004-06, depending mainly on awareness build-up by owners and equipment and management capacities of public and private emptying services.

Use in Agriculture vs. Disposal

Disposal on the landfill is operationally simple, as the landfill is adjacent. The dewatered sludge can be landfilled directly after removal from the treatment plant. The landfill space required is minor in comparison to the space required for solid waste disposal. Problems might arise eventually with the mechanical stability of landfill, because the sludge layers reduces the shear stress within the landfill. Reuse in agriculture requires efforts for marketing and commercialization, but bears the advantages of generating revenues. The net revenues from selling biosolids can contribute to partially cover O+M cost. Nam Dinh's agriculture, which is in great need for organic fertilizer to maintain or restore the soil's humus layer, could be supplied with a high quality product. The traditional reuse of human waste is going to be cut off because bucket latrines are replaced by septic tanks. The use of treated septage would thus restore this reuse practice in a hygienically safer way. From a sustainability point of view, reuse of organic waste should almost always be the preferred solution. Septage is a type of organic waste, which can be relatively easily treated to hygienically safe reuse, as, unlike WWTP sludge and solid waste, it is rarely contaminated with toxic chemical compounds.

Appropriateness of Managerial and Technical Options

The use of technologies and management concepts adapted to local conditions is extremely important for the successful implementation of proposed measures. Any expensive high-tech solution or organizational concepts directly transferred from different contexts implicate very high risk of failure. The proposed measures must be acceptable for Nam Dinh authorities and population and they must be compatible with

Vietnamese reality. The municipality of Nam Dinh must be able, financially, technically and with its human resources, to operate the proposed system and as well to extend it to satisfy future demands.

Characteristics of the FS delivered to a future treatment plant

Representative sampling of faecal sludges, which will typically be delivered to the treatment plant under consideration, was not possible during the four-month planning Study period. Septage will be the predominant type of sludge to be treated, as bucket sludge quantities will rapidly decrease due to the replacing of bucket latrines by septic tanks. It was considered expedient to use, as a first approximation, raw septage data collected at AIT (Bangkok) over a four-year period (1997-2001) in the course of a joint AIT/EAWAG septage treatment project. Table 1 shows the concentrations of the main constituents as found in Bangkok septage. These figures were used to carry out the preliminary design of the three proposed treatment options. The figures are means from 150 samples.

Table 1 Characteristics of septage based on 150 samples of vacuum truck contents collected in Bangkok from 1997-2001 (Koottatep et al. 2001)

Constituent		Concentration	
		Range	Mean
TS	[mg/L]	2,000 – 67,000	19,000
TVS	[mg/L]	900 – 52,500	13,500
SS	[mg/L]	1,000 – 44,000	15,000
BOD	[mg/L]	600 – 5,500	2,800
TCOD	[mg/L]	1,200 – 76,000	17,000
TKN	[mg/L]	300 –5,000	1,000
NH_4	[mg/L]	120 – 1,200	350

Pre-Selecting Options for FS Treatment

Fig. 1 shows schematically the array of theoretical options of FS treatment, from which options considered feasible for Nam Dinh were selected and elaborated to allow in-depth evaluation.

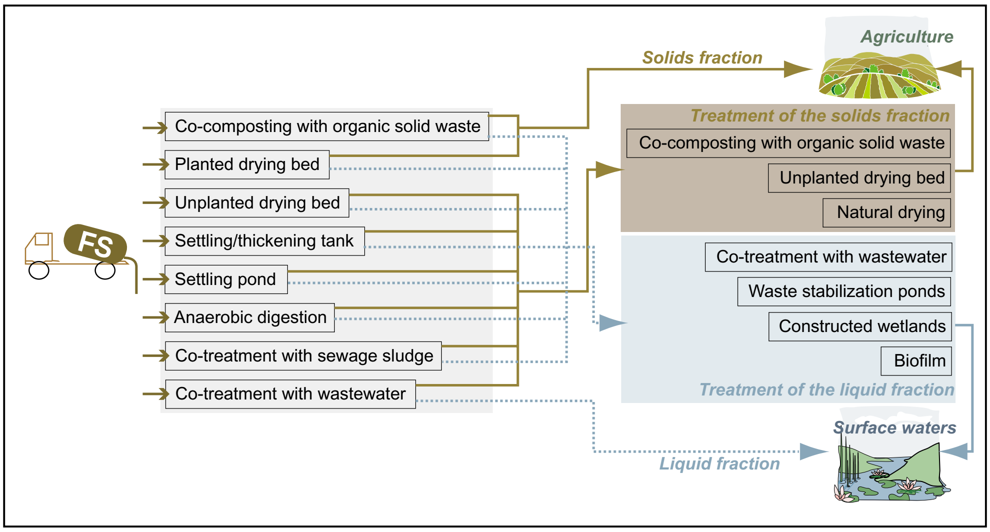

Fig. 1 Theoretical Options for Treating Faecal Sludges

In Table 2 below, the options considered unfeasible are listed and reasons for their exclusion indicated in an abbreviated manner.

Table 2 FS treatment options considered unfeasible for Nam Dinh and reasons for their exclusion

Option	Reasons for being considered unfeasible for Nam Dinh
• **Landfilling of raw septage**	- Increased leaching of contaminants from the solid waste - Physical instability of landfill - Soon to be prohibited (solid waste standard TCVN 6696)
• **Co-treatment with sewage or sewage treatment plant sludge**	- No sewerage, hence, no sewage treatment in Nam Dinh at present or in the near future - Sewage sludge chemically more contaminated than FS
• **Anaerobic digestors**	- Large proportions of easily decomposable organic constituents in septage have already been digested during storage in the septic tanks - Communal plants require some technical sophistication and gas must be "marketed"
• **Co-composting of raw septage with solid waste**	- Septage may be co-treated only at small proportions due its wetness

Three options considered feasible

The following options (core treatment processes) are considered potentially feasible under the socio-economic, technical and institutional conditions prevailing in Nam Dinh (which may be typical of other cities in Vietnam):

- Constructed wetlands
- Sludge drying beds, and
- Settling/thickening followed by pond treatment

Table 3 contains a description of the core treatment units contained in each of the options in a summarised form. Fig's. 2a – 2c show the functional sketches of these options. Also shown is the polishing treatment required for biosolids and liquids. With all three options, biosolids safe for use in agriculture can be produced, yet with different investment and operating cost and varying land requirements.

Table 3 Process description, design basis, and modes of construction and operation for the pre-selected treatment options

Constructed wetlands	Sludge drying beds	Settling/thickening followed by anaerobic pond treatment
Process description • Dewatering through percolation and evapotranspiration • Mineralization and hygienisation of solids through prolonged storage • Filtration and bio-chemical stabilisation of the liquid during percolation • Percolate polishing in a separate stabilisation pond or in the landfill leachate pond	***Process description*** • Dewatering through percolation and evaporation • Filtration and bio-chemical stabilisation of the liquid during percolation • Post-treatment (storage or composting) of solids for hygienisation • Percolate polishing in a separate stabilisation pond or in the landfill leachate pond	***Process description*** • Primary settling in tanks • Secondary settling and anaerobic treatment in a pond • Liquid polishing in a separate stabilisation pond or in the landfill leachate pond • Post-treatment (storage or composting) of solids for hygienisation
Design basis Loading rate: 250 kg TS / m2 · year ***Structure*** • 2 CW units @ 100 m^2, 50 cm gravel and sand filter, drainage system, planted with marsh plants • Tank for septage receiving, pump for CW unit loading • Open vault for percolate collection, pump for percolate evacuation ***Mode of operation*** • Each unit: continuos loading for 4 years, then sludge removal ➔Sludge removal once every 2 years	***Design basis*** Loading rate: 200 kg TS /m2 · year ***Structure*** • 5 DB units @ 50 m^2, 50 cm gravel and sand filter, drainage system • Tank for septage receiving, pump for DB unit loading • Open vault for percolate collection, pump for p. evacuation ***Mode of operation*** • Each unit: loading for 3-5 days, drying for 10-15 days, sludge removal ➔Sludge removal every 3-5 days	***Design basis*** *Settling tanks* • Loading period: 28 days • Solids accumulation: 0.1 m^3/m^3 of septage • Max. depth of accum'd. solids: 0.5 m ***Settling ponds*** • Solids accumulation: 0.025 m^3/m^3 of septage • Max. depth of accum'd. solids: 0.5 m ***Structure*** • 2 settling tanks @ 40 m^2, 1.5m effect. depth, reinforced concrete structure, baffled at inlet and outlet • 1 settling pond, 120 m^2 x 1.0 m ***Mode of operation*** • Each tank: 4 weeks loading, liquid evacuation, 4 weeks drying, sludge mixing with rice husk and removal • Pond: Sludge removal once per year

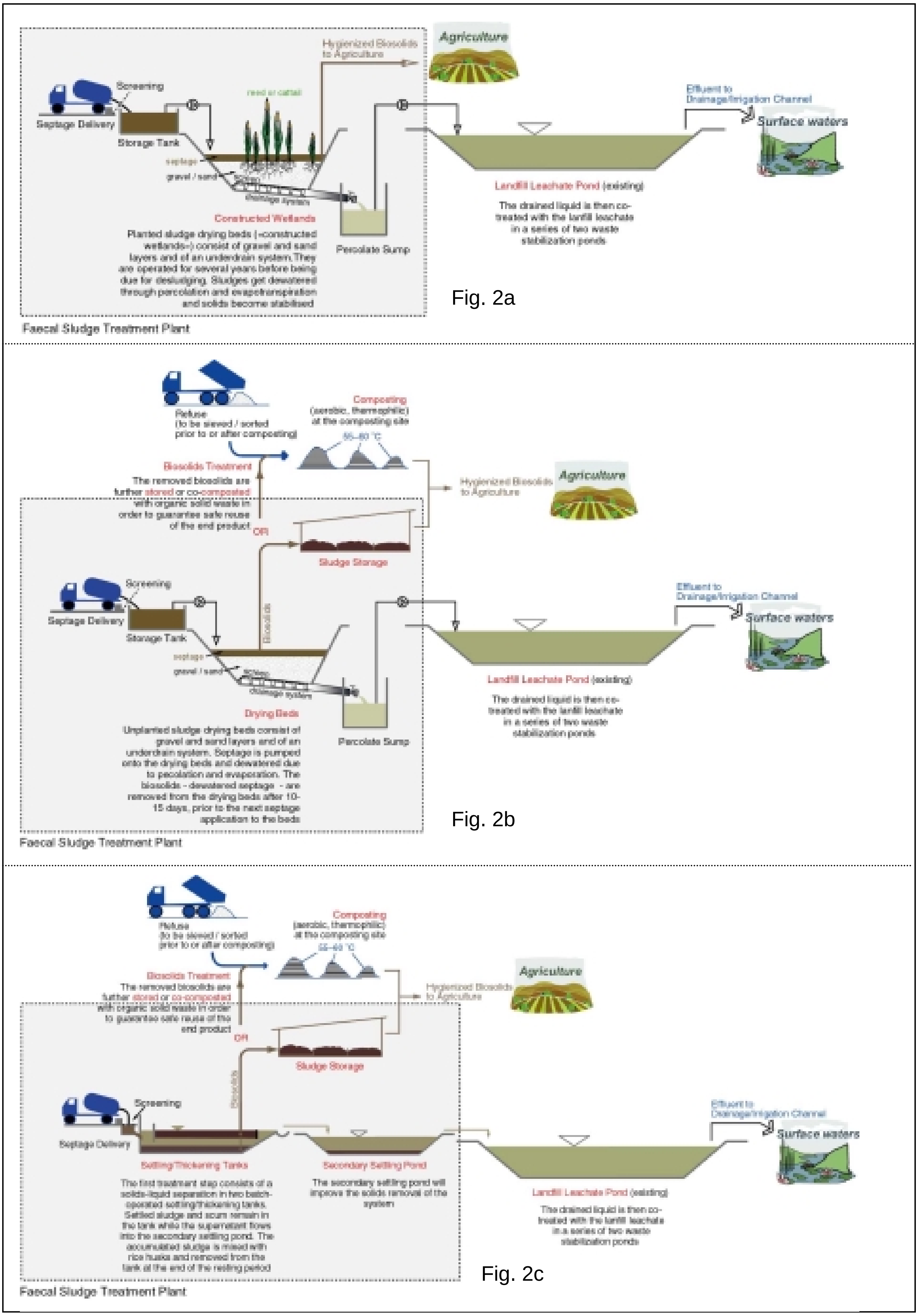

Fig. 2 a-c Functional Sketches of the Pre-Selected Treatment Options: a. Constructed wetlands; b. Sludge drying beds; c. settling/thickening and sedimentation / anaerobic pond

Table 4 shows the expected quantities and characteristics of biosolids as produced in the three selected options.

Table 4 Quantities and characteristics of biosolids produced in the three selected options

	Constructed wetlands	Drying beds	Settling tanks and pond
Dewatered sludge (biosolids) produced from 2,500 t of septage	75 t	110 t	300 - 450 t*
Biosolids mass as percent of raw septage mass delivered	3 %	4.5 %	12 - 18 %
Water content	70 %	60 %	85 %
Expected content of viable pathogens (notably worm eggs)	Very low	Considerable (very low after post-treatment)	Considerable (very low after post-treatment)

* This includes rice husks added to the settling tank/pond biosolids.

What treatment option to select ?

Criteria for Evaluation of Treatment Options

A detailed comparison and evaluation of various treatment options constituted the core component of the Study. Table 5 lists the criteria, which were formulated to make comparative judgements of the three options, considered feasible for the City of Nam Dinh.

Table 5 Criteria for selecting FS treatment options for Nam Dinh

Performance criteria	Process Simplicity and Reliability Criteria	Cost-related criteria
• Consistency and biochemical stability of biosolids • Hygienic quality of solids • Quality of liquid effluent	• O+M requirements • Skills required for operation and supervision • Risk of failure related to installations or to managerial or procedural measures:	• Land requirement. • Investment costs • Operation and maintenance cost

The stakeholders judging on the preferred treatment option will do the weighting of criteria. The Consultant, in his report, evaluated each of the three options against the above criteria. This, in combination with criteria weighting will allow planners and decision-makers to arrive at an informed choice.

Investment cost for any of the three options amount to $ 16,000-17,000. Estimated yearly O+M cost vary from $ 1,400 to $ 2,000 and $ 4,900 for the wetlands, sludge drying beds and settling tank/pond based systems, respectively. Net land requirements for the wetlands plant amount to 200 m^2; for the drying beds plant: 250 m^2 (drying beds) + 40 m^2 (for extended storage of dewatered/ semi-dried biosolids), and for the settling tank/pond system: 160 m2 (tank and pond) + 85 m^2 (for extended storage of biosolids).

The wastewater standard applicable for effluents from (wastewater) treatment facilities is the *Industrial Wastewater Discharge Standard* (TCVN 5945-95). The standard specifies allowable concentrations for discharge into water bodies of class A (water used for drinking water), class B (water used for recreation or agriculture), or class C (permit needed). Class B standards for BOD, COD, SS and coliforms are 50, 100, and 100 mg/L and 10,000 MPN/100 mL, respectively. Disposal of sludge on landfills is not allowed. For biosolids, the Consultant proposes to use the quality guideline of 3 – 8 nematode eggs / g TS (Xanthoulis and Strauss 1991). The value is based on the WHO guideline for wastewater used in irrigating vegetable which may be eaten uncooked (WHO 1989) and on a manuring rate of 2-3 t TS / ha · year.

Conclusions and Recommendations

Strategic options to enhance FS collection

In the "old days", when family and public bucket latrines were the prevailing excreta disposal option, FS collection was effectively managed by farmers and micro entrepreneurs, fetching the FS from people's homes and from public toilets. Faecal sludge was and continues to be in high demand for agriculture and aquaculture, currently fetching prices from up to 500-1,000 VND (US $ 0.03-0.07) per kilogram. In contrast, septage tanks are emptied when users choose to call upon the emptying service or are forced to do so if their in-house drainage system becomes blocked due to excessive solids build-up within the septic tank. As a consequence, septic tank emptying is a very irregular event, resulting in excessive solids carry-over into the surface drains, leading, in turn, to increased pollution and health risks, to the blockage of surface drains and increased inundation. Also, the rate at which faecal matter is recycled to fields and fishponds is only a fraction of what it was but a few years ago. Farmers deplore the decreased availability of organic fertilizer.

In the Study, two options have been suggested on how the rate of septic tank emptying and, hence, of septage being treated and recycled to agriculture, may be increased. The first builds on the short-term solution, i.e. improving the PUEs' technical and managerial capacities to satisfy demand for septic tank emptying at all times. The point-in-time when a septic tank should be emptied is left exclusively to the house owner. Intensive promotion for increased frequency of septic tank emptying should be started immediately (and may have to be maintained over several years), equally so the subsidizing of collection fees. Close collaboration between or even the merging of UCMC and URENCO will be very important. Policies and rules regulating the role of private entrepreneurs in septage collection might be formulated and implemented.

The alternate model for septage management would rely on introducing regular emptying. This would call for intensive political discussions with the participation of citizens' representative bodies prior to introducing such a system. The responsibility for emptying would thus rest in the hands of the municipal authority which sets the frequency, implements an adequate fee structure and regulates private entrepreneurs' participation. Fees would become part of the house owners' monthly services bill such as for water supply. This strategic model would obviously depart from the current system whereby it is left to the house owner to decide about the time of emptying. Such voluntarity has, of course, great advantages, may, however not be adequate to minimize environmental pollution, drain clogging and health hazards caused by inadequate management of the on-site sanitation system prevailing in Nam Dinh (and in many other cities of Vietnam).

Treatment and Reuse

Appropriate options for the treatment of faecal sludges in Nam Dinh were identified, designed and critically evaluated. They allow for the production of hygienically safe biosolids, which may be purchased by farmers for use as a soil conditioner and partial fertilizer. Once treatment is in place, indiscriminate disposal of untreated faecal sludge is to be prohibited.

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