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Global Review of Sanitation System Trends and Interactions with Menstrual Management Practices

Report for the Menstrual Management and Sanitation Systems Project

Marianne Kjellén, Chibesa Pensulo,
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Stockholm Environment Institute
Kräftriket 2B
106 91 Stockholm
Sweden

Tel: +46 8 674 7070
Fax: +46 8 674 7020
Web: www.sei-international.org

Director of Communications: Robert Watt
Publications Manager: Erik Willis
Layout: Alison Dyke

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CONTENTS

INTRODUCTION

This review of sanitation system trends and interactions with menstrual management practices has been conducted as part of the broader project on Menstrual Management and Sanitation Systems.

It starts with a review of trends in the development of urban sanitation systems and then explores the interaction between menstrual management and sanitation systems, mainly relating to the issue of disposal of used menstrual blood absorption materials. Finally, it proposes a framework of interactions by positioning a range of issues of particular relevance for menstrual management into the different parts of the sanitation system.

In the framework (chapter 3), the most important menstrual management and sanitation system interactions from the perspective of the user occur at the toilet, where the facility conveniently serves (or not) the needs of the user, and to some extent conditions the behavior related to the disposal of used menstrual material. Further downstream, in the collection, conveyance and treatment parts of the system, the interactions relate mainly to the way menstrual waste has been disposed of and its potential to cause and contribute to blockages and the filling up of receptacles.

Generally, the appropriate disposal method for used menstrual pads and such material is with solid wastes that are collected separately from feces and urine. Where such arrangements are lacking or not used, menstrual waste may be inappropriately disposed of through sanitation facilities, which may lead to clogging or system failure. Understanding the interactions between menstrual management and sanitation is therefore important for improving sanitation functional access and ensuring benefits and sustainability of sanitation systems.

The review of interactions between sanitation systems and menstrual management (chapter 2) indicates that blockages are a real issue in the management of sewerage systems, and that menstrual products – particularly those composed of super-absorbent materials – contribute significantly to the problem. Relating to other systems, interactions are less clear, though non-degradable material may contribute to filling up of latrines and need to be manually removed for the use of excreta material in ecological sanitation systems.

It appears that information to the users is central for their behavior with regard to disposal of used menstrual materials. Still, in order to avoid absorption materials to be disposed of with feces, it is absolutely necessary to have bins or other receptacles available. Further, hand-washing facilities need to be situated within the toilet facility for menstruating women and girls to be able to handle menstrual hygiene. Still, menstrual management issues are rarely considered in the design of sanitation systems.

Looking towards future urban sanitation systems, one may assume that they need to save water, pollute less, and become more cost-effective. Looking at the general trends, however (chapter 1), we see an increased reliance on water-borne systems. In Latin America and China, these systems appear to be sewered, whereas in many parts of Asia an increasing proportion of the urban population relies on septic tanks. In Sub-Saharan Africa, however, traditional latrines mostly cater for the growing urban populations.

1. URBAN SANITATION SYSTEM TRENDS IN THE DEVELOPING WORLD

By Petter Nordqvist with Marianne Kjellén

This chapter provides a picture of the urban sanitation situation in different developing regions. It is based on the collection of survey and census data which has been compiled by 'type of facility' in five regions or countries of roughly comparable population size: Latin America, China, India, South East Asia, and Sub-Saharan Africa.

The overall conclusion, as shown in the Table 1 above, is that sewer systems predominate in China and Latin America, septic tanks in South East Asia, (traditional pit) latrines in Sub-Saharan Africa, while the picture is more mixed with regard to India.

Regarding the development trends, the water-based systems are increasing faster than urban population growth in all five areas except Sub-Saharan Africa. In China and Latin America, it is extended sewer networks that account for the growth of water-based systems, while in South East Asia it is predominantly the construction of septic tanks which lies behind the increase. For India, the results are ambiguous, as different sources tell different stories. It seems however that water-based systems, including pour-flush latrines, are increasingly common, although there is a variety of systems as well as a high rate of open defecation. In Sub-Saharan Africa, the traditional pit latrines seem to be the only facility type whose prevalence increases at a faster rate than the urban population. Still, there are also many people using improved latrines, septic tanks, or who remain with no facility at all. Rough linear trend lines fitted to the findings are shown on the next page.

This review of urban sanitation system trends is mostly based on data available through the WHO/UNICEF Joint Monitoring Programme (JMP), which is available online (see UNICEF/WHO JMP, 2010b). The JMP, in turn, uses data from various global surveys, such as USAID's Demographic and Health Surveys (DHS), the UNICEF-monitored Multi-Indicator Cluster Surveys (MICS), WHO's World Health Surveys (WHS), National Censuses, and more.

The JMP data is updated biannually. Their way of reporting, however, is generally limited to displaying sanitation systems as "improved", "shared", "unimproved", or "open defecation" (see http://www.wssinfo.org/definitions-methods and latest update WHO/UNICEF JMP, 2010a). In contrast, the present review uses the same data with a focus on the evolution of the different types of facilities in urban areas. In this way, it presents a view that is not available elsewhere in the JMP regular reporting. Notwithstanding, the underlying data used for reporting on sanitation coverage is obtained from various global and national surveys, and has some strong limitations. There are different ways of classifying sanitation facility types, and definitions change over time.

Table 1 – Dominating urban sanitation system and urban populations, by region/country

Region / Country	Dominating urban sanitation system	Urban population (2005)
Latin America	Sewer system	433 million
China	Sewer system	531 million
India	Mixed	326 million
South East Asia	Septic tanks	246 million
Sub-Saharan Africa	Latrines	269 million

Further, while more recent surveys often provide high-resolution data on facility types, older ones generally comprise fewer categories. Hence, the trend lines shown in this review are limited to the broader categories. These broad categories are:[1]

Flush or pour flush (all bluish categories)

- Latrines (all greenish categories)
- No facility (open defecation, orange category)

[1] These four categories are non-exclusive: Flush and pour flush (including all water-based systems); Estimated access to sewerage; Latrines (all types); and No facility. Pour flush latrines are counted in both water and latrine categories, but mostly exist to some degree in India and parts of South East Asia. Most of the flush systems that are not connected to a sewer are instead connected to a septic tank

Urban population	Rough trend in sanitation systems

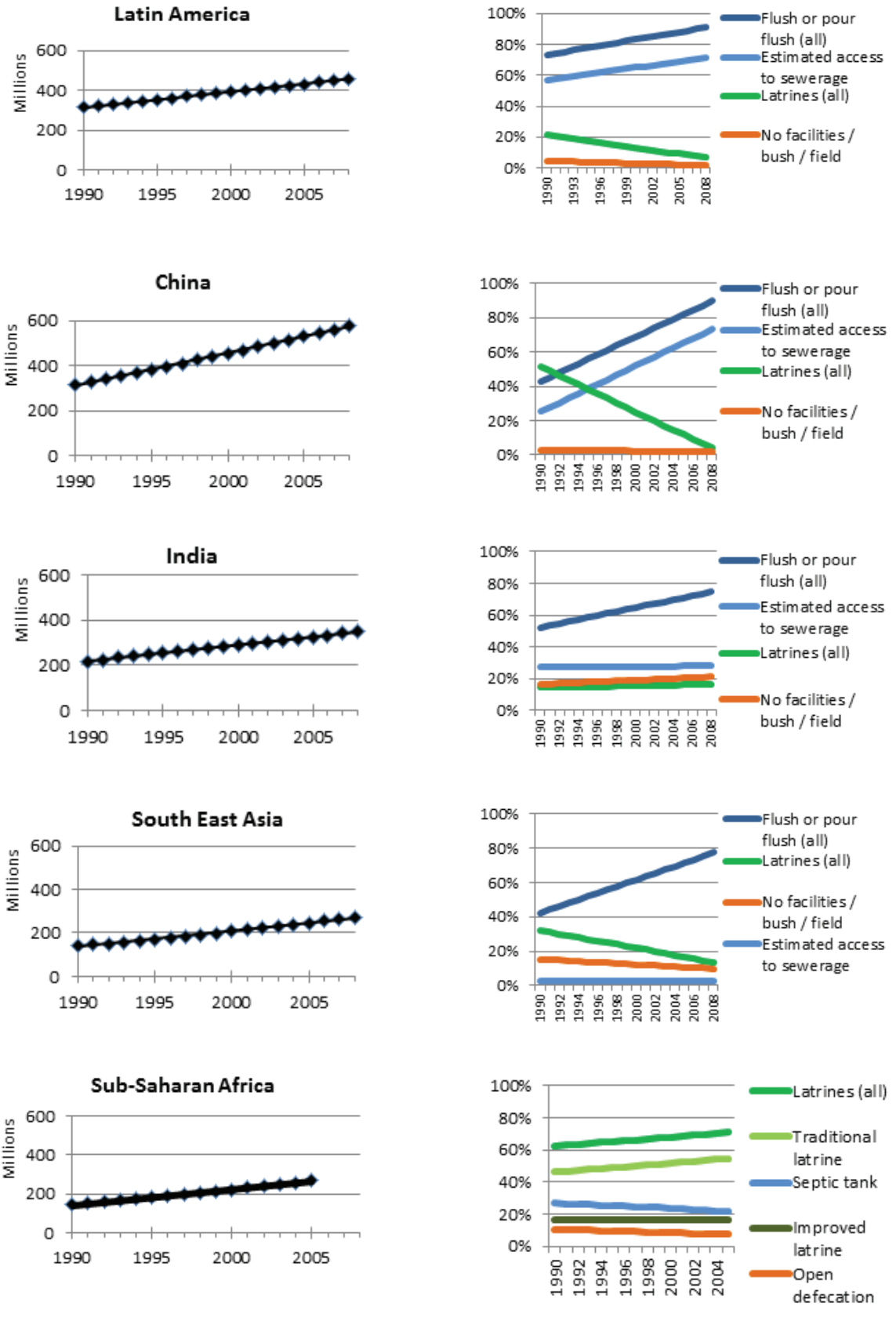


Figure 1: Urban population and sanitation system trends, by region/country

- Sewerage access (special JMP estimate)

For certain countries (further below), survey data is also presented by year in the highest resolution possible, color coded into the following categories:

- Bluish colors: Water based facilities (including pour flush latrines in cyan)
- Greenish colors: Latrine type systems (including pour flush latrines in cyan)
- Yellow: Unknown data, or data marked as "other" (also including rare occasions of hanging latrines)
- Red/orange: No facility, bush, or field (also called "open defecation")
- Black: Composting toilet (rare)

The trend lines on the urban population development are based on statistics and forecasts for each country as provided by the UN Department of Economic and Social Affairs (ESA, 2007).

SUB-SAHARAN AFRICA

This section provides an overview of the distribution of different sanitation systems in urban areas of Sub-Saharan Africa, by both using generalized regional trends and specific country-level data. The results draw from data available through the JMP as well as the Africa Infrastructure Country Diagnostic (AICD).[2]

Current situation

The AICD estimates that in 2005, traditional latrines constituted about half of the urban sanitation solutions of Sub-Saharan Africa, while septic tanks accounted for one fourth, improved latrines for one seventh, and open defecation for the remaining eight percent (Table 2). [3,4]

In the corresponding JMP data, open defecation also account for eight percent, while sanitation systems are listed as improved (44 percent), shared but otherwise improved (31 percent), or unimproved facilities (17 percent) without any further detail on what specific systems are used (UNICEF/WHO JMP, 2010, Annex B). An important note here is that the JMP report half of the "traditional latrines" as improved latrines, and the other half as unimproved, while the AICD keep the original categories that are used in the surveys, thus avoiding such estimates (Morella *et al.*, 2008a, p.4).

The difference between African countries (and between cities) may of course be high. Some common patterns in urban (and rural) sanitation system distribution recognized by the AICD and are discussed in the following section on typologies. Here, as well as above, sewer systems are not listed individually but as part of the "septic tank" category, although especially some of the countries with a "bi-modal" pattern in fact have some or even a high extent of sewer connections.

African urban sanitation typologies

Whereas a presentation of trends provides hints to the evolution over time, typologies of different combinations of systems provides a view that is more sensitive to the variation of technologies forming part of an urban system as a whole. The majority, and many of the poorest countries, relies mostly on traditional latrines, with other systems being poorly developed (fig 2). The wealthier countries, most of them in Southern Africa, have a high proportion of users relying on flush toilets (most commonly septic tanks which may reflect private/individual investment, or to a lesser extent – water-borne sewerage) and a large minority mostly relying on traditional latrines (labeled the 'bimodal

[2] Africa Infrastructure Country Diagnostic (AICD), commissioned by the Infrastructure Consortium for Africa after the 2005 G-8 summit at Gleneagles, report on African sanitation systems in higher detail than the JMP, and their data is the main source for this summary. They have used survey data from the DHS and MICS surveys, and classify sanitation systems in the categories of "septic tank" (including the more uncommon sewer-connected flush toilets), "improved latrines" (SanPlat, Ventilated Improved Pit (VIP) latrines, or pit latrines with slab), "traditional latrines" (basic pit latrines), and "open defecation". Unlike JMP, they do not put shared facilities in a specific category, do not divide traditional latrines into "improved" or "unimproved" categories, and do list flush toilets as a specific category, although sewer-connected toilets are not treated individually (Morella *et al.*, 2008a).

[3] Note that sewer connections are not mentioned in these simplified statistics but are included in the "septic tank" category. This is partly because the DHS surveys used do not differ between sewer or septic tank flush toilets, and partly because the authors estimate that sewer connections are much less common than septic tanks. They do however mention that some richer countries such as South Africa and Namibia have a higher rate of urban sewer connections, as well as some areas in Senegal, Tanzania and Zambia (Morella *et al.*, 2008a, p.7).

[4] Improved latrines are in AICD statistics defined as SanPlat, Ventilated Improved Pit (VIP) latrines, or basic pits with slabs. This differs from the JMP definition, where half of the reported "traditional latrines" are also considered improved. (Morella *et al.*, 2008a, p.4)

Table 2: Patterns of access to sanitation in 2005, from Morella et al (2008a).

	Open defecation	Traditional latrine	Improved latrine	Septic tank
Urban	8	51	14	25
Rural	41	51	5	2
National	34	52	9	10

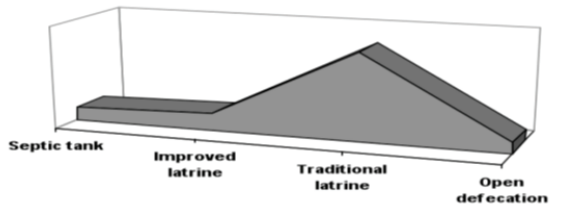


Figure 2: Predominance of traditional latrine (Central African Republic, Chad, Comoros, Republic of Congo, Ethiopia, Guinea, Lesotho, Malawi, Mali, Mauritania, Mozambique, Nigeria, Tanzania, Uganda, Sudan and Democratic Republic of Congo.) From Morella et al (2008a)

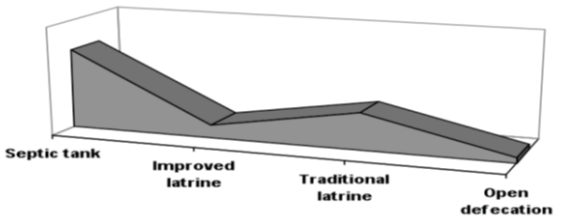


Figure 3: Bi-modal Pattern (Côte d'Ivoire, Gabon, Kenya, Namibia, Senegal, South Africa, Zambia, Zimbabwe.) From Morella et al (2008a)

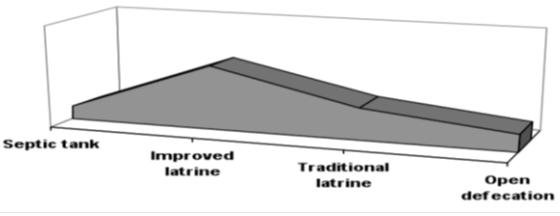


Figure 4: Predominance of improved latrine (Benin, Burkina Faso, Cameroon, Ghana, Madagascar, Niger, Rwanda.) From Morella et al (2008a)

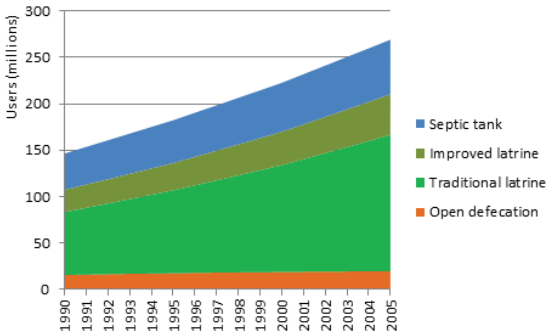


Figure 5: Estimate of sanitation facility development in urban areas of Sub-Saharan Africa

pattern' fig 3). Another group show high prevalence of improved pit latrines, presumably catering for the upper-income echelons in locations where flush technology is sparse (fig 4).[5]

Trend

Drawing from the AICD statistics in Morella *et al.* (2008a; 2008b), a generalized trend in urban sanitation facility development has been calculated (Figures 5 and 6).[6] These figures are rough estimates, but correlate with the numbers presented by the UNICEF/WHO JMP (2010a), where urban open defecation is reported to have declined from 11 percent to eight percent since 1990, while the proportion of improved, shared and unimproved facilities remain largely unchanged.

These figures suggest that while urban populations in Sub-Saharan Africa have increased by as much as 83 percent from 1990 to 2005, the construction of sanitation facilities has on the one hand followed in the same pace, but their relative shares have been almost constant. The construction of traditional latrines seems to have been slightly faster than the population growth, while flush toilets have gotten somewhat less common.

[5] Morella et al (2008) – based on Figure C: Patterns of access to sanitation across countries, p. viii

[6] Figures 2a and 2b have been created by calculating on the reported rate of change for each country (Morella *et al.*, 2008a, Table 2.4) counting from the latest available year (Morella *et al.*, 2008b, Tables 2.2, 2.3 and A1), and weighted by population (Population Division…, 2007). The 24 countries used in the analysis comprise about 72 percent of the Sub-Saharan African population. The numbers have been generalized and scaled up to represent the whole population of the region.

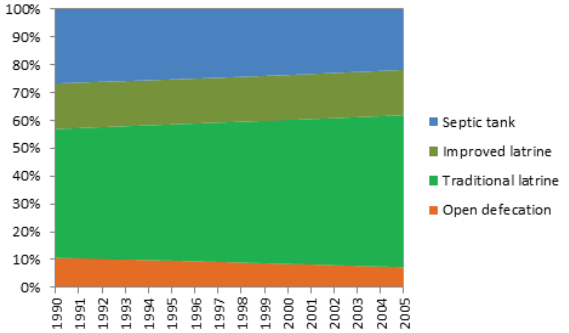


Figure 6: Estimate of sanitation facility development as a percentage of urban facilities

The proportion of open defecation has decreased, but the actual number of practitioners has increased by an estimate of 400,000 people.

When looking at individual countries however, it is clear that the local changes are sometimes large compared to the continental "status quo". In Figure 7, four countries with very different situations and development trends are shown. Burkina Faso and Ethiopia are both countries with little use of flush toilets, but while Burkina is reported to have had a great expansion of improved latrines (seemingly upgrading traditional latrines to improved ones), Ethiopia still has a high dominance of traditional latrines, though making progress in reducing open defecation. Kenya and Senegal are two countries with high shares of flush toilets, but Senegal's expansion of these facilities are unmatched by Kenya's more stagnant development. Note that these pictures do not show the actual development year by year, but only a generalized trend, and that the results may be exaggerated and can at times be attributed to changes in categorization rather than to physical changes on the ground (especially in the Burkina Faso case, where a high rate of change was reported).

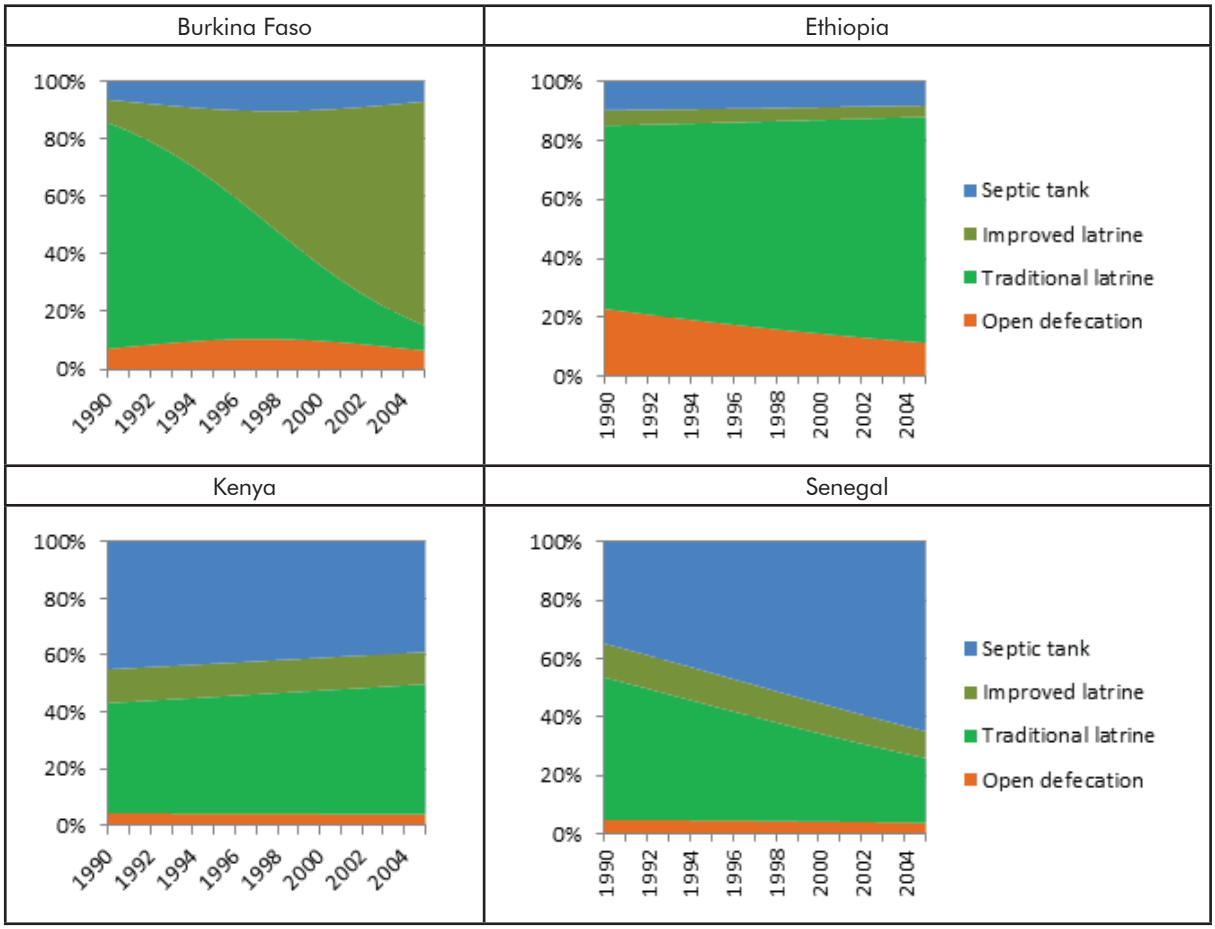


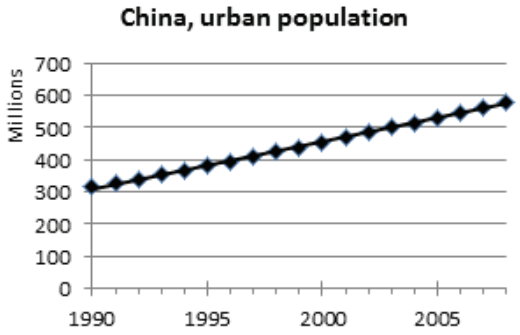
Figure 7: Four countries with different estimated trends in urban sanitation system development

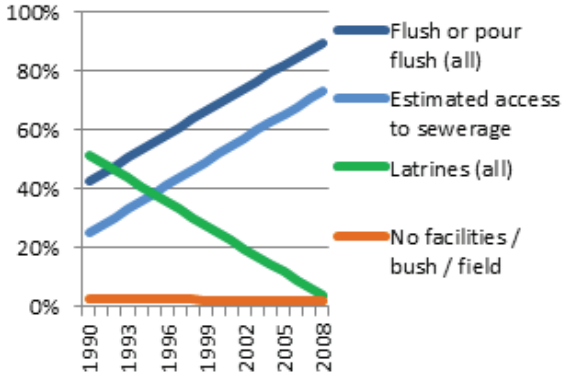
CHINA

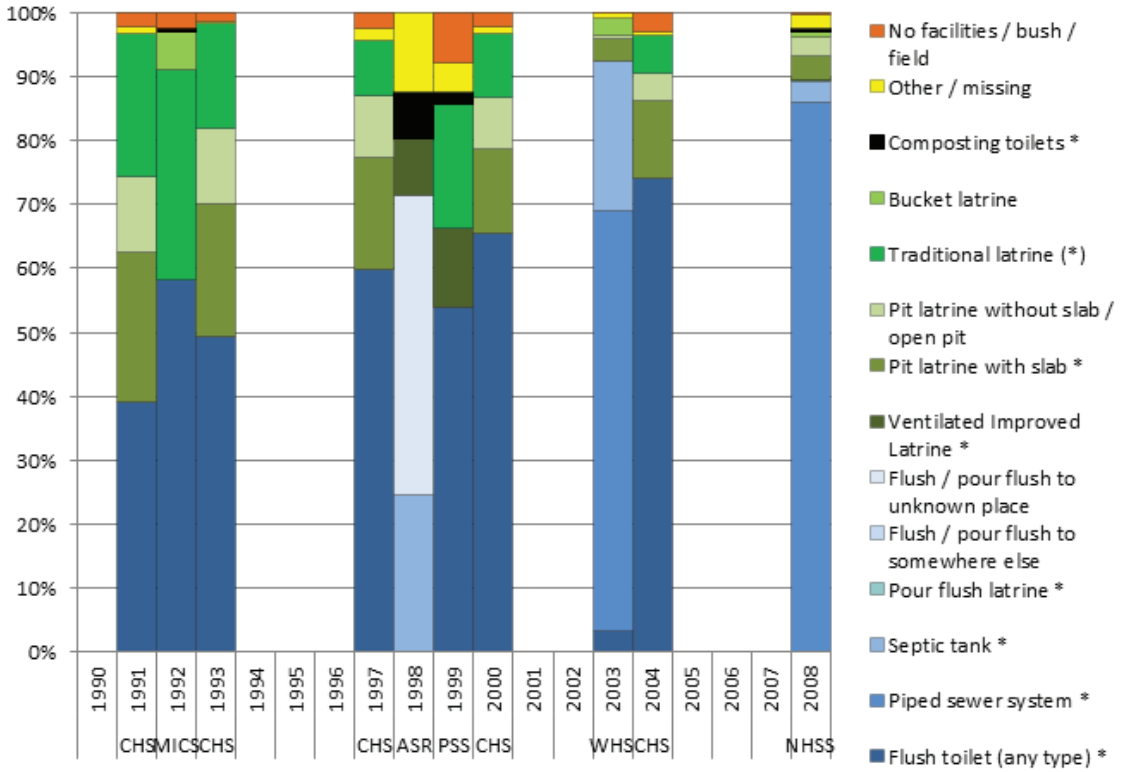
In China, the large and rapidly growing urban population has to a very large extent been provided with sewer connected flush toilets, according to the reported numbers. Even though actual details on piped systems are only reported in two surveys (WHS, 2003; NHSS, 2008) there are few contradictory indications, as most surveys report a steady increase of "flush toilet" systems.

If the latest numbers are correct, latrines are now uncommon in urban China (from having served around half the urban population 20 years ago), and open defecation is almost nonexistent. Septic tanks are used by some (or at some places) but are much less common than piped sewer systems.

It should be kept in mind, however, that there may be large regional and local deviations from the presented averages.





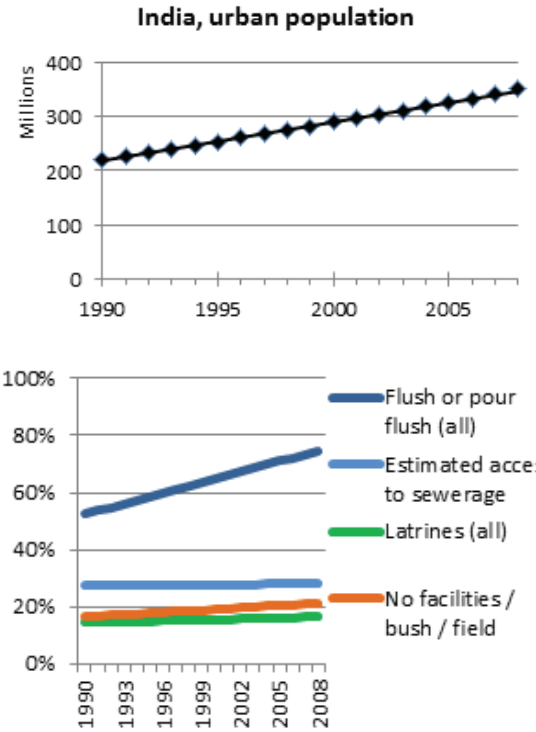


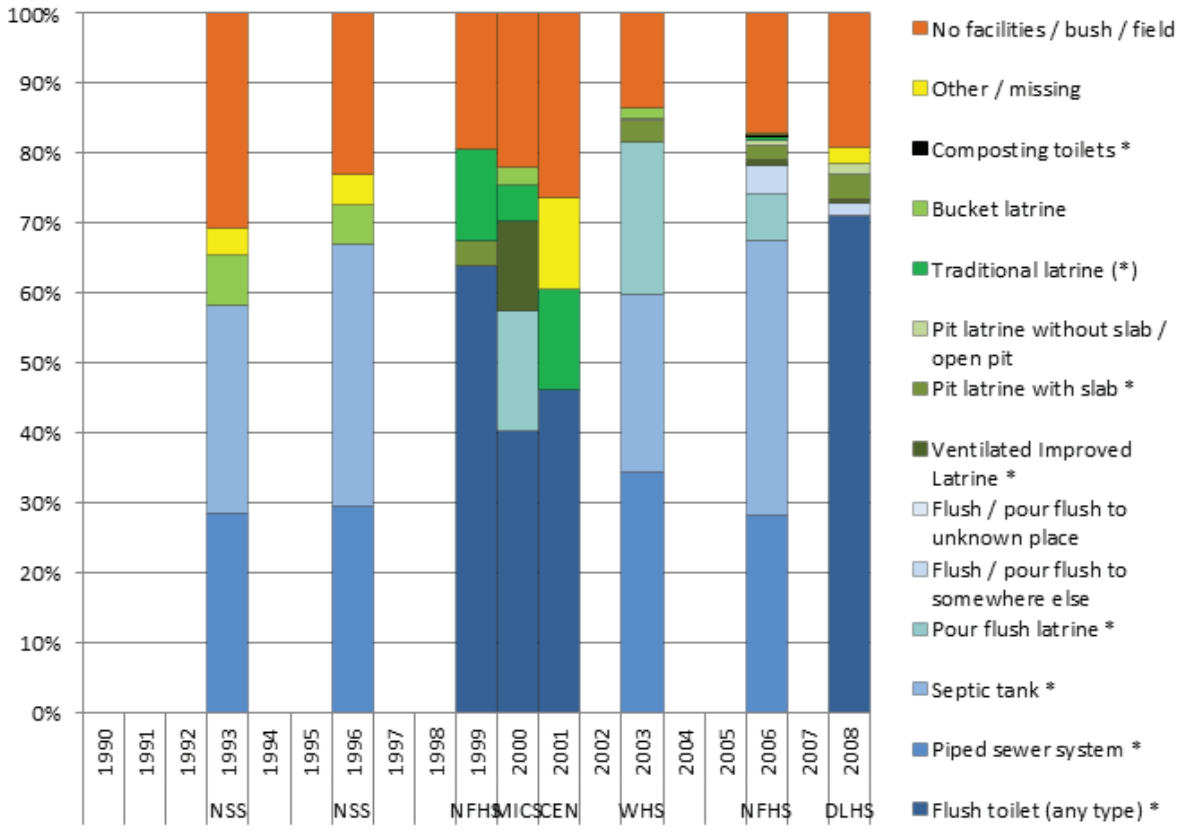
INDIA

India has had an urban population increase by about 60 per cent since 1990, and sanitation systems have by large increased relatively. The majority uses some kind of flush or pour flush toilet, but neither pit latrines nor open defecation is uncommon.

Although the data is partly ambiguous, there seems to have been an increase in flush toilet coverage although the percentage with sewer connection has remained almost constant, which would imply an increase in septic tanks and/or a move from traditional latrines to pour flush pit latrines.

As in the case with China, the reader must remember that these figures are only an average of a large number of cities and regions that may separately be very different.





SOUTH EAST ASIA

This section provides an overview of sanitation systems in urban areas of South East Asia, defined as the Asian region stretching south of China, east of Bangladesh and north of Australia. Data from five countries that together comprise about 85 per cent of the South East Asian urban population have been used to analyze the trends in that region.[7] Still, the region's urban population is smaller than that of India and only half that of China.

The general trend is here a large increase in flush toilets while sewer systems are persistently rare and slowly expanding, suggesting that use of septic tanks (and sometimes pour flush pit latrines) is now the dominating practice. As these systems grow, latrines and open defecation are decreasingly common but are still relevant parts of the picture.

different situation, although the trend towards water based systems is shared between all countries.

In the relatively small country of Cambodia, most urban residents use either a flush toilet facility or no facility at all. During the past 15 years (or more), the first of these categories has been increasing, while the other has decreased. The uncommonly detailed statistics from the country show that the share of the population using toilets connected to septic tanks has also been increasing to some extent (from around 20 to 30 percent), while traditional latrines are now a rare sight. There are however, still many people with no access to any toilet facility.

Indonesia is the largest of the South East Asian countries, with about 50 per cent of the region's urban population. Here, septic tanks have gained ground at the cost of traditional latrines, and are now available to

Table 3 - Estimated urban populations and degree of urbanization in the investigated countries. Source: ESA (2007).

Country or region	Urban population (2010)	Urban/total population
South East Asia	286,579,000	48 %
Cambodia	3,470,000	23 %
Indonesia	128,634,000	54 %
Philippines	61,731,000	66 %
Thailand	22,118,000	34 %
Viet Nam	26,191,000	29 %

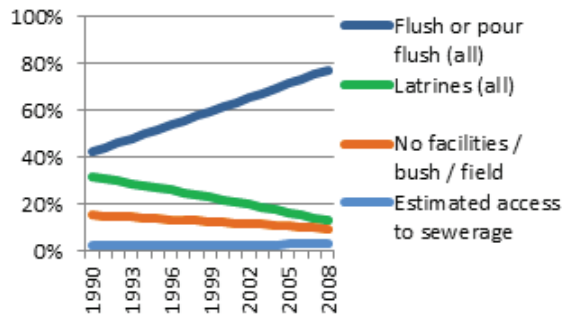


Figure 8: Best-fit trend lines for different types of sanitation facilities in urban areas of South East Asia.

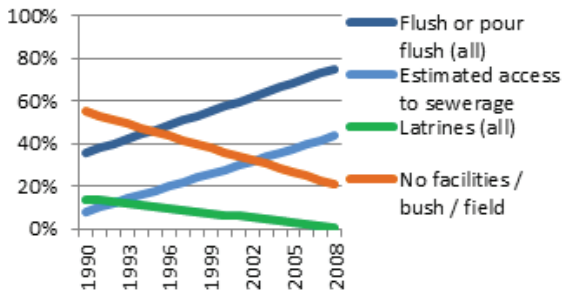


Figure 9: Best-fit trend lines for different types of sanitation facilities in urban areas of Cambodia.

These results are dominated by the weight of Indonesia (see below), but the picture is also quite consistent with situation in the Philippines, Thailand and Viet Nam. The smaller country of Cambodia shows a somewhat

almost 80 per cent of the inhabitants. Of those who remain, about half use some type of latrine while the other half practices open defecation. Notable here is that there is no piped sewer system in Indonesia.

7 Cambodia, Indonesia, Philippines, Thailand, and Viet Nam.

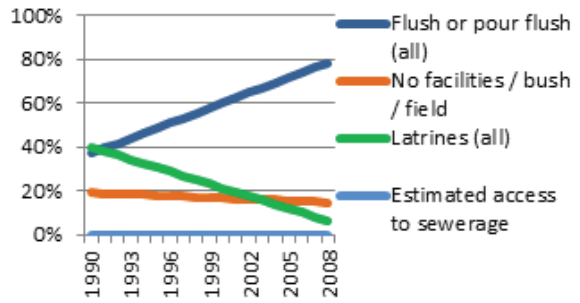


Figure 10: Best-fit trend lines for different types of sanitation facilities in urban areas of Indonesia

From the Philippines, there are only six survey data points used for analysis, with partly unclear implications. What is clear is that most people use some type of water based toilets, while some five per cent still practice open defecation.

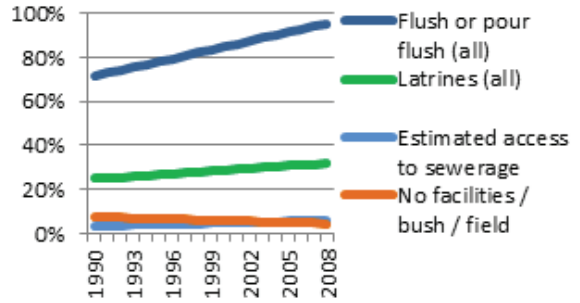


Figure 11: Best-fit trend lines for different types of sanitation facilities in urban areas of the Philippines.

Two surveys report that pour flush pit latrines account for more than half of the facilities, while surveys from 1990 and 2008 report septic tanks as the absolutely dominating technique. One possible explanation to this is that pour flush toilets connected to septic tanks may be used, but are reported differently by the different survey institutions. It is however clear that sewer connections, though existent, are not common. In the trend line figure, latrines (green line) show a growing trend because of the large amount of pour flush latrines, but the amount of dry latrines is actually small and decreasing.

The low amount of data points for Thailand makes the trend lines hit unrealistic values, but the conclusion is clear: Thailand has had a high coverage of flush toilets since before the 1990's and is now close to 100 per cent flush toilet coverage. According to the 2005 Multiple Indicator Cluster Survey (MICS), piped sewer systems account for some 10 per cent of the connections, while septic tanks represent the other 90 per cent.

Viet Nam has had a rapid increase in water based systems since the 1990s, of which septic tanks make

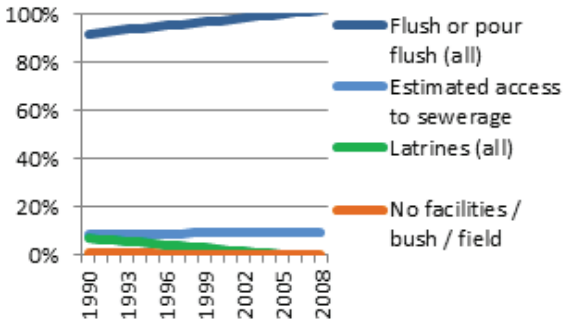


Figure 12: Best-fit trend lines for different types of sanitation facilities in urban areas of Thailand

out the largest part but pour flush latrines also has (or at least has had) an important part. Consequently, dry latrines are now less common and there are only a few percent of the urban populations who do not have access to any toilet facility. Remarkable for Viet Nam is that composting toilets stand out as a relevant fraction of the sanitation systems (in rural areas used by as much as 25 per cent of the population, but less common in urban settings).

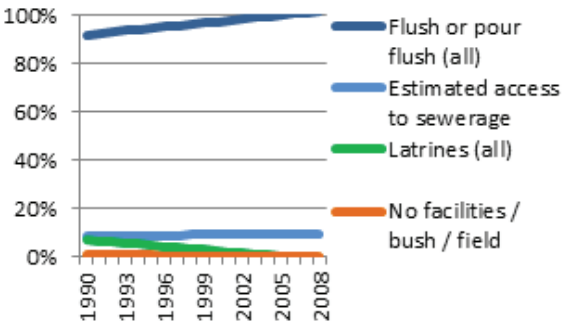


Figure 13: Best-fit trend lines for different types of sanitation facilities in urban areas of Viet Nam

Table 4 - Estimated urban populations and degree of urbanization in the investigated countries (ESA, 2007)

Country or region	Urban population (2010)	Urban/total population
Latin America	471,177,000	79 %
Caribbean	28,288,000	67 %
Cuba	8,525,000	76 %
Dominican republic	7,182,000	71 %
Haiti	4,988,000	50 %
Central America	110,136,000	72 %
Guatemala	7,111,000	50 %
Mexico	85,839,000	78 %
South America	332,753,000	84 %
Argentina	37,640,000	92 %
Brazil	172,177,000	87 %
Chile	15,250,000	89 %
Colombia	35,951,000	75 %
Peru	20,700,000	72 %
Venezuela	27,315,000	94 %

LATIN AMERICA

This section summarizes the trends and general situation with regard to sanitation system developments in of urban areas Latin America (including the Caribbean). Data from eleven countries, together comprising about 90 per cent of the Latin American urban population, have been used to analyze the developments of the region (Table 4).

The trend line is simplified, but suggests that around nine out of 10 people in urban Latin America would today have access to a flush toilet, most of which are linked to piped sewer systems.

Most of the development the past 20 years has been on replacing latrines with flush toilets, and serving the expanding cities with such systems. The rate of open defecation shows a decrease and is low in most countries, but there may also be an underestimation as this parameter is not listed in all countries, including the very populous Brazil.

Given their size and predominance in the statistics, data for Brazil and Mexico are discussed separately below.

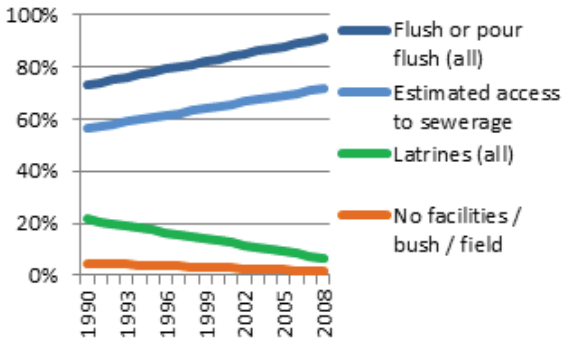
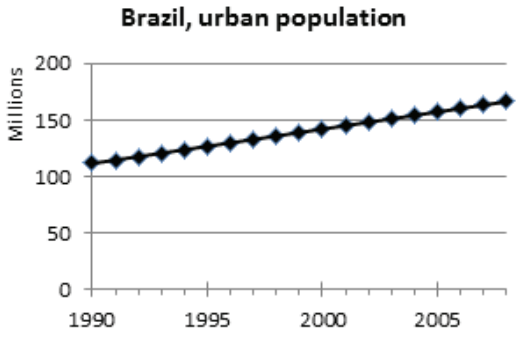


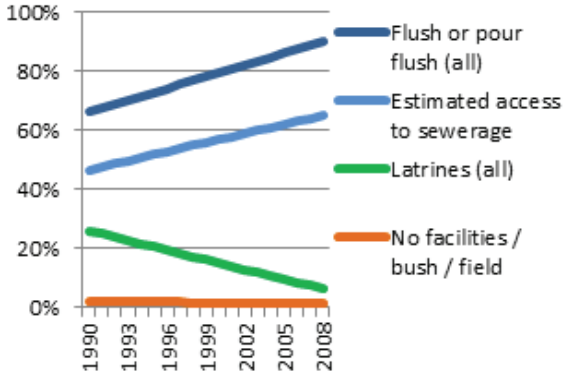
Figure 14: Best-fit trend lines for different types of sanitation facilities in urban areas of Latin America

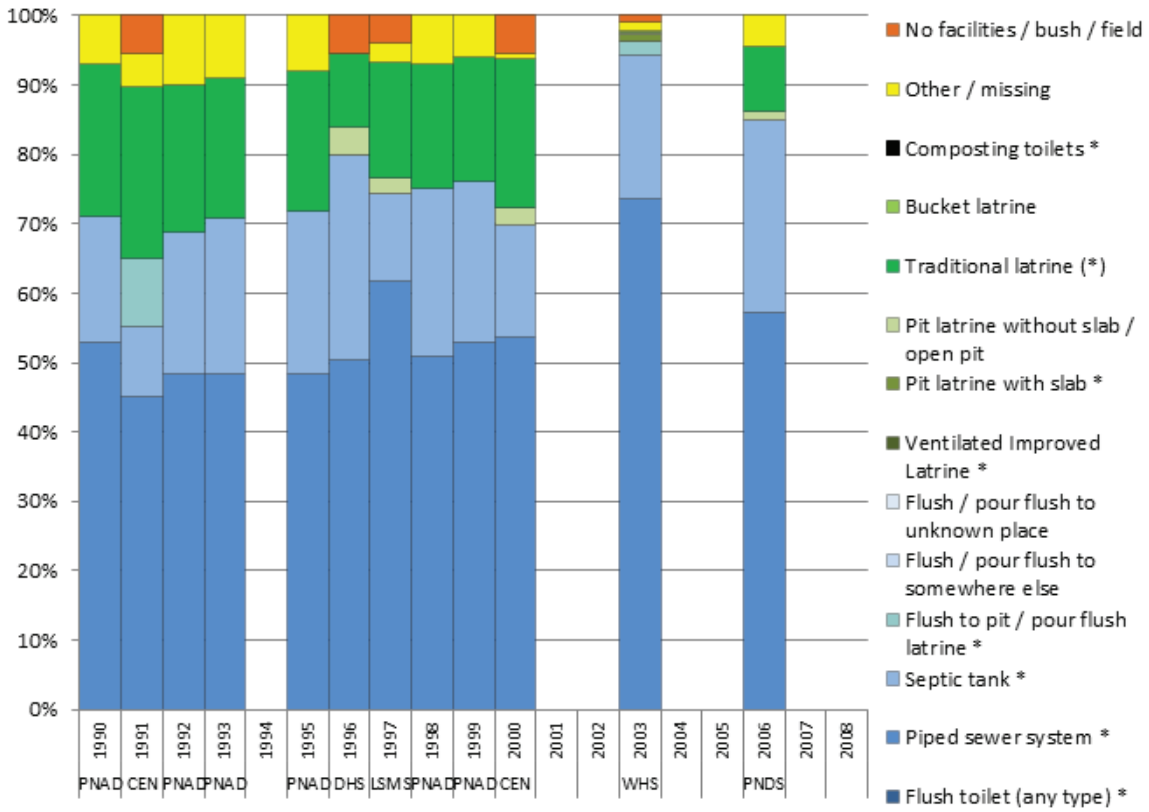
Brazil

The Brazilian statistics are dominated by National Household Samples (PNAD), which do not show much change over the years and does not list open defecation. They are however quite consistent with other survey data, and the trend in Brazil seems to be an increase in piped sewer systems, which now serve the majority of the population.

Septic tanks are the second most common conveyance technique, used in 15-25 per cent of the systems. Latrines are decreasingly common but are still used by millions of people. The degree of open defecation may be underestimated in the trend line, but is not higher than six per cent (9 million people) in any surveys.





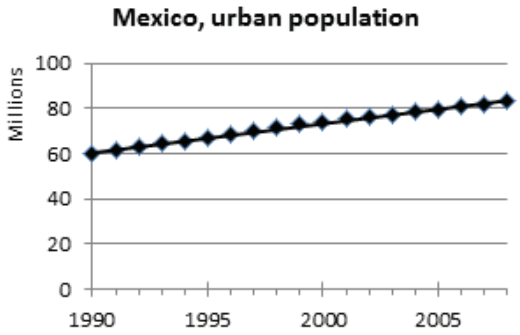


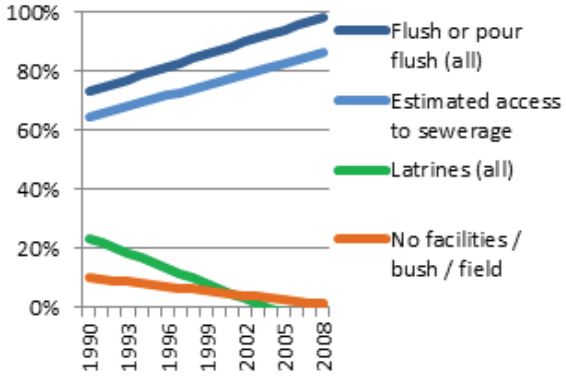
Mexico

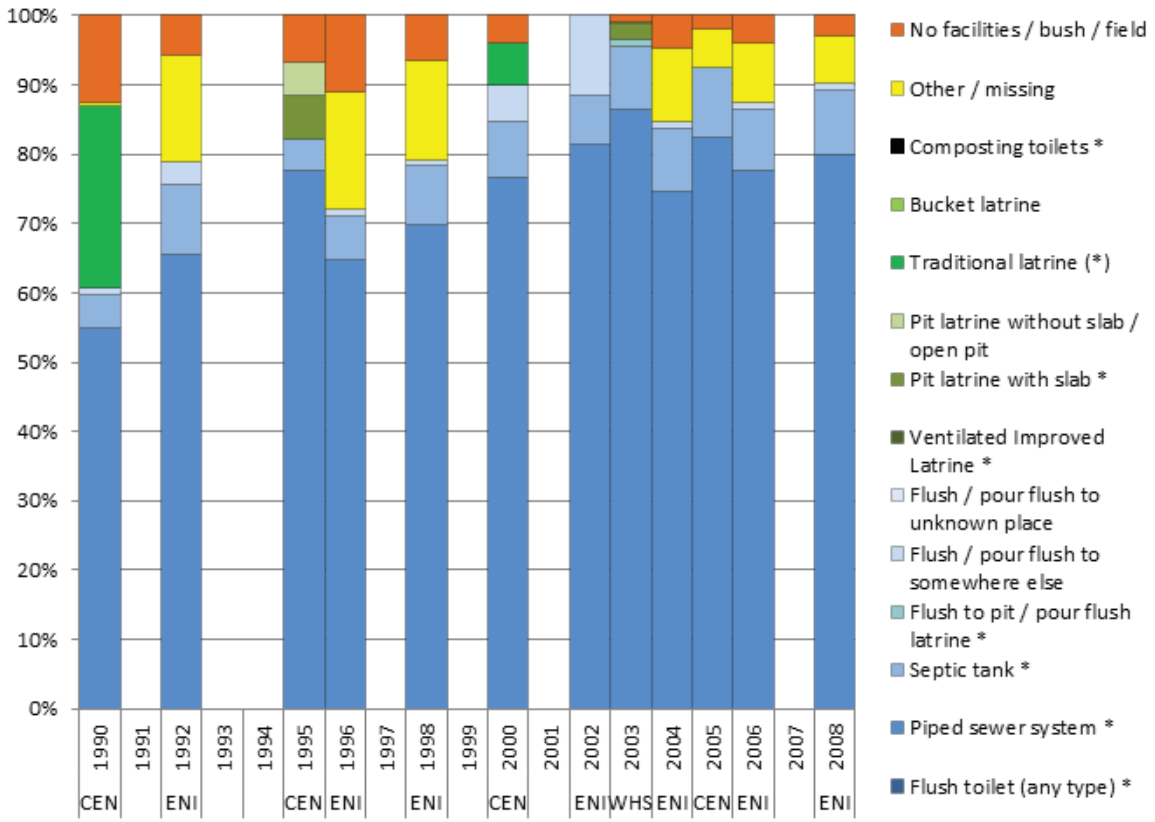
Statistics from Mexico show an increase in sewer system access, now serving somewhere around 80 per cent of urban populations. Another 10 per cent or so have flush toilets connected to septic tanks, but of the remaining tenth, not much can be said. Latrines are still, contradictory to what the trend line tells us, existent, but seem to be reported as "other" or "unknown" in many data sources.

In the JMP collected statistics of Mexico, open defecation has been listed separately from the other percentages, giving sums of more than 100 per cent when open defecation is added. These number may thus be slightly skewed (to an underestimation), and a few million people may still be without toilet facilities.

Most Latin American countries show similar pictures, with predominantly water-based systems. Sewer systems are generally on the increase, often at the expense of other water-based (pour-flush) systems. Exceptions are some of the Caribbean countries, where latrines feature more strongly as urban facility type.







Survey abbreviations – relating to detailed survey presentation figures

As used by JMP

ASR	Census / National Census / Demographic Census / Censos Nacionales de Población y de Vivienda
CEN	Census / National Census / Demographic Census / Censos Nacionales de Población y de Vivienda
CHS	China Economic, Population, Nutrition, and Health Survey
DHS	Demographic and Health Survey
DLHS	District Level Household Surveys
ENI	ENIGH : Encuesta Nacional de Ingresos y Gastos de los Hogares
JMP	Global Water Supply and Sanitation Assessment 2000
LSMS	Living Standards Measurement Survey
MICS	Multiple Indicator Cluster Survey
NFHS	National Family Health Survey
NHSS	National Health Services Survey
NSS	National Sample Survey
PNAD	Pescuisa Nacional por Amostra de Domicilios
PNDS	Pescuisa Nacional
PSS	Population Sampling Survey
WHO	The International Drinking Water Supply and Sanitation Decade
WHS	World Health Survey

Disclaimer

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2. THE INTERACTIONS BETWEEN SANITATION SYSTEMS AND MENSTRUAL MANAGEMENT

By Chibesa Pensulo

This chapter describes the problems caused by disposal of menstrual absorption materials via the fecal collection arrangements of sanitation systems, and how the sanitation systems available to menstruating women and girls affect their disposal habits. The last section of the chapter discusses the alternative: disposal of menstrual waste via the solid waste system.

This overview is based on a review of articles published in journals and reports available over the internet, complemented with interviews and email correspondence with sanitation specialists and managers.

WATER-BORNE SYSTEMS

The disposal of used menstrual absorption materials via the toilet is habitual in many countries. The practice stems from the historical link associating health risks with human waste (Ashley et al, 2005). It was thought that the public would be best protected from health risks by flushing away potentially hazardous materials. In more recent times, concerns around the environmental impacts of this waste (Lynch, 1996), as well its effects on sewerage systems, have led sanitation researchers and practitioners to discourage this method of menstrual waste disposal.

According to the Museum of Menstruation and Women's Health (www.mum.org), the first disposable menstrual pads were produced in the 1890s, and menstrual tampons in the 1920s. Since their introduction, the use of disposable menstrual products has grown rapidly, in both developed and developing countries. This has led to unmitigated rises in the quantities of used menstrual products clogging up sewer lines, entering wastewater treatment plants and, subsequently, ending up in rivers, lakes and seashores (Shoemaker, 2008). Sewerage systems are designed to carry only excreta, water and tissue paper; any other materials flushed down toilets may cause blockages.

The contribution of menstrual waste to the problem of blocked sewer lines is the subject of this sub-chapter.

Causes of blockages in sewerage systems

Sewerage systems are made up of pipes and joints of varying sizes. The sewer line leading out of an individual dwelling should have a diameter of at least 100mm. Depending on the configuration of the sewerage system and the number of connections it serves, the diameter of the pipes in the system range from 100mm to several meters.

In conventional sewerage systems, menstrual products tend to cause blockages in smaller diameter pipes while in larger diameter pipes they are normally found in combination with coagulated grease, in what London's Thames Water Company calls 'fatbergs' (Thames Water, 2011). According to a research project conducted in the UK in 2008 (Arthur et al, 2008), there are several factors which may indicate that an individual pipe has an increased propensity to block. Among these factors are:

Menstrual pads | Tampon and applicator | Panty liner

Disposable menstrual products

- Network type – Combined sewers (which convey sewage, rain water and, in some cases, pretreated industrial effluent) tend to block more commonly than sanitary sewers (which only convey sewage) because of the higher quantities of oil, grease and solid materials that enter combined sewers.

- Surcharge state - Surcharging occurs when the flow in the sewer becomes pressurized, that is, the bore of the pipe is filled. When this happens, in most cases, wastewater rises up the manhole shafts.

- Proximity to a junction - It was noted that many blockages occurred just upstream of a junction.

- Self-cleansing gradient – If a pipe has been laid at a gradient that is not sufficient to ensure self-cleansing velocities of sewage flow through the pipe, solid materials settle in the pipe and eventually block it.

- Large direct inputs - pipes that receive disproportionately large direct inputs relative to rest of the system tend to block most frequently. Sewer lateral lines from public toilets may be particularly prone to blockages for this reason, among others.

- Pipe size - the majority of the pipes that get blocked frequently are 225mm in diameter or less.

Construction of infrastructure systems is subject to human error. Thus, with some pipes in a sewerage system predisposed to blocking due to the above-listed factors, entrance of menstrual waste into the system aggravates the problem.

In Latin America, relatively new models of sewerage systems, generally referred to as condominial systems, make use of small-bore pipes. The diameter of the sewer lines within the condominiums (housing blocks) is 100mm, while the network pipes have diameters of up to 250mm. Records from Brasilia, Brazil, showed that despite the smaller diameters of the condominial sewer lines, these systems experienced fewer blockages than the conventional sewer systems within the same city. This was attributed to the higher level of user information and participation in the construction and maintenance of the condominial systems (Melo, 2005).

Magnitude of the problem

Managers of various utilities rate the contribution of menstrual waste to the blockage problem differently, but they all report finding large quantities of menstrual waste in the material removed when unblocking pipes. According to eThekwini Water and Sanitation, the utility serving the South African City of Durban and its environs, blockages arise from misuse of the city's ageing sewerage system. The material removed from blocked pipes and joints include large quantities of rags, menstrual pads and tampons. Menstrual pads are considered particularly problematic because they swell up when they are saturated with fluid. Blockages occur more frequently in areas with low water pressure because the toilets have to be flushed with less water, thus there is insufficient water to carry the solid materials through the sewer system. Thus, the solids build up in the pipes and block them.[8] Bordering eThekwini's coverage area is Ugu District Municipality, which also records numerous blockages on a daily basis. Each blockage takes Ugu's sewer maintenance staff an average of four hours to resolve and is a major cost to the municipality. Pipes as large as 450mm in diameter have been found clogged by pads and tampons.[9]

In Tanzania, the Dar es Salaam Water and Sewerage Corporation records an average of 150 blockages per month, costing the company an estimated USD 25,000 per month to rectify. Blockages are frequently found in pipes that had been laid at low gradient and in areas that have inadequate water supply. Another frequent problem reported is the use of manholes at lateral connections as refuse disposal points. Thus, refuse becomes lodged in the sewer pipes and blocks them. Menstrual pads, tampons, rags and cotton wool are commonly found among the materials that clog sewer lines.[10]

A utility in neighboring Kenya reports a similar situation. Mavoko Water and Sewerage Company in Kenya is responsible for water supply and sewage disposal in the Athi River district of Eastern Kenya. The company's sewerage services manager indicates that menstrual pads alone constitute about 40 per cent of the material hauled from blocked sewers. Because the frequency of blockages exceeds the company's ability to respond immediately, blockages are often only resolved the day after they are reported, leading to sewage backflows into homes, which is a serious health hazard.[11]

[8] Personal communication (email):N. Macleod, eThekwini Water and Sanitation

[9] Personal communication (telephone and email): P. Mayeza, Ugu District Municipality

[10] Personal communication (telephone and email): M. Mulagwanda, Dar es Salaam Water and Sewerage Company

[11] Personal communication (email): J. Mbula, Mavoko

Manila Water Company in the Philippines has over 144,000 sewer connections and receives an average of four reports of blockages per day in its 305km sewer network, with most blockages caused by menstrual pads, diapers, rags, underwear, socks and condoms. Pads and rags are always among the debris hauled from clogged sewer lines. Most blockages occur at the joints between household sewers (laterals) and main sewer lines, as these connections are often not correctly installed[12].

Sana'a Water and Sanitation Local Corporation in Yemen records about 1,200 sewer blockages each month, costing the company an estimate of USD 24 000 per month. Menstrual pads are found among the materials removed from blocked pipes in 80-90 per cent of cases.[13]

According to the manager of a sanitation service company in Cochabamba, Bolivia, the most frequently found materials when unblocking sewer pipes are grease, soil sediments, menstrual products and children's toys. Menstrual products, especially pads, are mostly found in sewer blockages at schools, and account for 60 per cent of such blockages. Blockages are also common in the city's outlying expansion zones.[14] Cochabamba's municipal water and sewerage authority, SEMAPA, serves 370,000 homes and recorded 1,399 sewer blockages in 2010. The authority estimates that 30 per cent of sewer blockages in the city are caused by menstrual pads and rags.[15]

A respondent from the Mar del Plata Sanitation Works in Argentina reports that menstrual products, condoms and disposable diapers frequently clog the pumps in the city's sewer pumping stations.[16]

These problems are by no means limited to cities in low- and middle-income countries. According to an American article, water and public works department websites of cities across the United States often include advisories that suggest ways customers can prevent blockages. Although each department has specific recommendations, one warning is suggested frequently to avoid plumbing problems and sewer line blockages: should not be flushed down toilets. Several of these websites indicate that sanitary napkins are a major cause of sewer line blockages and backflows (Shoemaker, 2008).

In a study that collated information from utilities in England and Wales, it was found that the annual frequency of sewer line blockages ranges from 0.0250 to 0.2252 per kilometer of pipe (Arthur et al, 2008). In another study, sewer blockages were investigated over a three year period using U.K. Water Authority records. It was found that no blockage appeared to have been caused exclusively by sanitary solids, but by other factors with sanitary solids accumulating subsequently (Ashley et al, 2005). Thames Water, which provides water supply and sewerage services to the city of London and the Thames Valley, reports clearing about 55,000 blockages from its sewer network each year, at an annual cost of GBP 12 million, and that 7,000 customers experience sewer backflows and spillages into their homes and gardens as a result of these blockages (Thames Water, 2011). Used cooking fat poured down kitchen drains, menstrual waste flushed down toilets, and other materials mix and coagulate into a greasy mass, the biggest of which caused a 1.2 meter thick blockage in one of the city's largest sewers in July 2010. A contributing factor to this problem is that some producers of menstrual absorption products label their products as 'flushable', giving customers the impression that these products will disintegrate in the sewerage system. But this is erroneous, as 'flushable' tampons take about six months to biodegrade, and pads are only partly biodegradable and even then only over several months or years. Thames Water is running a campaign called 'Bin it – don't block it' to educate its customers on what should not be disposed of down drains and toilets.

Thus, it is evident that blockages in sewerage systems are a major problem all over the world, and that used menstrual products are a significant contributing factor to this problem. A disturbing trend has been observed in some developing countries, with the advent of plastic pipes: instead of calling for a professional to unblock a lateral sewer line, some property owners simply cut the pipe at a point before the blockage, leaving raw sewage to run out into the street.[17]

Water and Sewerage Company

12 Personal communication (email): N. Carbon, Manila Water Company

13 Personal communication (email): I. A. Al-Mahdi, Sana'a Water and Sanitation Local Corporation

14 V. Poclava, ServiMASTER, interviewed by M.C. Arteaga, Fundacion Agua Tuya, 2011/07/11

15 A. Lizarazu, SEMAPA, interviewed by M.C. Arteaga, Fundacion Agua Tuya, 2011/07/14

16 Personal Communication (telephone and email): E. Peralta, Mar del Plata Sanitation Works

17 Personal communication (telephone and email): E. Huba, sanitation specialist

Alternative disposal methods for menstrual waste

Currently practiced alternatives to disposal of used menstrual absorption materials through sewerage systems are:

- Disposal of menstrual waste in bins, either in ordinary trash cans or specially designed 'feminine hygiene' bins, and
- Burning of menstrual waste at home or in incinerators installed in public bathrooms.

Ease and convenience seem to be key factors in women's selection of menstrual product disposal methods. A survey conducted in New Zealand revealed that menstrual products were disposed of by the majority of users in the easiest and most convenient way. Eighty percent of respondents flushed tampons down the toilet at home and work, sixteen percent of respondents indicated that tampons are disposed of in the household bin, and the remaining four percent burned their used tampons in an incinerator or home fire. Pads and panty-liners were wrapped in toilet paper and placed in household bins (73 per cent) or burned (27 per cent). One-third of all respondents indicated that where bins for menstrual waste are available in toilet cubicles, these were the principal disposal method used. Informants who disposed of tampons via the toilet did so because it was easy, convenient, habitual, and rid them of the waste quickly. They also believed that the sewerage system could cope with tampons. Pads and panty-liners were disposed of in the most convenient manner also - either in an incinerator where one was available or into a bin. None of the women surveyed admitted to disposing of pads and panty liners in the toilet, as they were aware that sewer blockages would most likely result (Lynch, 1996). Thus, it seems there is a distinct difference in the disposal of pads and tampons, with tampons being flushed down the toilet, and pads being disposed of by other means.

In the small-bore condominial systems parts of Brazil, user awareness campaigns were conducted during construction. Women were encouraged to treat menstrual waste as solid waste, to be disposed in the trash basket. This has proved to be successful, as a respondent reported that the maintenance team at the sewers and treatment plant had no complaints about menstrual absorption materials causing problems in the systems.[18]

[18] Personal communication (email): K.D. Neder, Companhia de Saneamento Ambiental do Distrito Federal

A cost-benefit analysis comparing the disposal of menstrual waste through the sewerage system and through the solid waste disposal system was conducted in Scotland from 1996 to 1999. The study compared the social, economic, environmental and technical benefits and costs of these disposal routes, and found that there would be considerable cost savings from even a 50 per cent change in public disposal habits from the waterborne to the solid waste route, savings which would initially be of direct benefit to the Water Companies and Water Authorities and ultimately passed on to customers. Furthermore, the increased amounts of materials which would be introduced to the solid waste collection system, approximately 0.3 per cent by mass from a 100 per cent habit change, were found to be negligible compared with the total amount of municipal solid waste that was currently being collected. As sanitary waste is, in any case, ultimately disposed to the same point as municipal solid waste, with sewage screenings going to landfill or incineration, there would be no difference in the ultimate fate of the sanitary solids removed from wastewater systems (Ashley et al, 2005). An additional benefit is the fact that there would be a decreased risk of menstrual waste ending up in water bodies.

The second option, incineration at the point of disposal, is relatively uncommon in urban areas in developing countries. It is used in public settings such as schools, but rarely in homes. There have, nonetheless, been some innovations in this disposal method. A project in the Tamil Nadu region of India has led to the construction of simple, low-cost incinerators in girls' toilets at several schools and women's sanitary complexes (Government of India, 2007). The incinerator unit is constructed on an outer wall of the restroom, with an inlet inside the restroom. The menstrual waste collected in the incineration unit is burned on a weekly basis.

However, it is a well-known fact that both landfilling and incineration pose hazards to public health and the environment. Thus, neither is an ideal solution to the menstrual waste problem. Used menstrual management products accumulate in landfills, as they are at best only partly biodegradable. Incineration releases dioxins and other noxious gases, causing respiratory illnesses, air pollution, and contributing to climate change.

Conclusion on water-borne systems

This review indicates that blockages are a real issue in the management of sewerage systems, and that menstrual products - particularly those containing superabsorbent materials – contribute significantly to the problem. The high absorbency of most modern menstrual pads is because they contain polyacrylate

superabsorbent polymers (Zohuriaan-Mehr and Kabiri, 2008), which can absorb extremely large volumes of liquid relative to their own mass (Horie et al, 2004). This highlights the need and potential for a re-introduction of reusable menstrual products, as well as the need for increased awareness on proper and safe methods for disposal of used menstrual products. From a system management point of view, it is important to ensure that the recommended methods for disposal are convenient for the women and girls to comply with, i.e. that materials and waste receptacles are physically available and attractive to use. Hence, there is a need for changes in menstrual product design, sewerage system management practices and personal menstrual waste disposal practices.

ON-SITE SYSTEMS

As highlighted in Chapter 2, in the developing world, more people are served by on-site sanitation than by sewerage systems. In sub-Saharan Africa, pit latrines are the most common sanitation facility in both urban and rural areas. In south-east Asia, septic tanks are the dominant form of sanitation. India and other South Asian countries have a broad mix of sanitation systems with no clearly dominant one. China and Latin America are the only developing regions in which sewerage is dominant, at least in urban areas. Waterborne sewerage systems are particularly rare in Africa. Pit latrines are not only are the most common form of sanitation in Africa, but are also the fastest growing.

Disposal of menstrual waste into pit latrines is a widespread practice in urban and peri-urban areas, both in Africa and South Asia. In a survey conducted in urban slums in Delhi, India, 92 percent of the respondents said they discarded the cloth they use during menstruation, whereas only 5.4 percent reuse cloths. Reuse of cloth was common in the villages; but in the slum areas, due to lack of space and privacy, this practice had largely been abandoned. Some respondents claimed that they had been advised by their mothers to dispose of their menstrual management products in pit latrines to prevent the materials from being seen by men or being used in witchcraft (Garg et al, 2001). Thus, it seems that in slums and other peri-urban regions, the quantities of menstrual management products disposed of in pit latrines is higher than in rural areas, where they are often reused several times and then buried.

Particularly in urban areas, sludge from on-site sanitation systems often ends up in sewer systems. Menstrual waste disposed of in on-site toilets can end up causing blockages in sewer networks, especially in areas with close proximity to sewerage systems. Pit latrine and septic tank sludge is often illegally disposed of down sewer manholes, increasing the likelihood of downstream blockage. To resolve this problem, specially designed discharge stations can be constructed to receive and retain sludge from on-site systems, then discharge it to the sewer when the flow is appropriate (Pickford and Shaw, 1997).

This sub-chapter is a compilation of reports and anecdotes on the interactions between menstrual waste and on-site sanitation systems.

Menstrual waste reduces the design life of pit latrines

Aerobic and anaerobic digestion processes break down organic matter in pit latrines. Accumulation of material in the pit is therefore due to a build-up of microbes, salts, non-biodegradable matter plus some undegraded, but potentially biodegradable material. The same principles apply to septic tanks, except that there is usually more water both entering and exiting the system, and much less solid waste (Schaub-Jones, 2011). Thus, the problem with disposing of menstrual waste into pit latrines is that causes the pits to fill up faster. This is particularly problematic if the pit latrine is shared by several families. The excreta in the pit decompose and decrease in volume, while the non-biodegradable components of menstrual waste accumulate and do not break down. Furthermore, once the sludge has been removed from the pit latrine, if it is to be used in agriculture, any waste that has not completely decomposed such as menstrual pads must be removed before the sludge can be composted or applied to farmland. The cost to remove, screen and dispose of menstrual management products from pit latrine sludge is high and not accounted for.

Tampons, cotton wool, toilet paper and organic materials used for menstrual management decompose in pit latrines and thus do not pose a problem, as long as the decomposition processes in the pit are working as they should. According to an international specialist in on-site sanitation, sanitary napkins decompose over a period of about one year, except for the plastic inlay.[19] Rags are the most commonly found menstrual absorption materials in pit latrines. They tend to bundle together into balls that clog the suction hose, or cannot be removed from the pit at all. Rags generally take much longer to decompose, and may not decompose at all if they are made of synthetic materials. A researcher studying decomposition rates of pit latrine contents

[19] Personal communication (telephone and email): E. Huba, sanitation specialist

reported finding significant quantities of rags in pit latrines in Ifakara, Tanzania.[20]

Menstrual waste poses problems in emptying pit latrines

In rural areas, once a pit latrine is full, it is normally covered with soil, a new pit is dug, and the toilet superstructure is moved or rebuilt. In urban areas, space limitations prevent this, and most pit latrines have to be emptied (Bhagwan et al, 2008). Septic tanks must be emptied periodically, depending on the regional climate, the size of the tank the use conditions. A general rule is to desludge the tank when it is two-thirds full (Pickford and Shaw, 1997).

Septic tanks are emptied using vacuum tankers. According to a respondent who manages a sanitation service company in Cochabamba, Bolivia, there are rarely problems in emptying septic tanks, unless accumulated waste is left for too long and becomes compacted in the tank.[21]

Pit latrines are mostly emptied manually, particularly in dense unplanned settlements where road access for a vacuum tanker would be impossible. There have been some innovations in pit latrine emptying equipment, with the development of the MAPET (Manual Pit Emptying Technology) and the Vacutug. But reports indicate that these are often not powerful enough to completely empty the pit, especially if the pit is deep and has been in use for several years. While it is easy to extract the low-density waste from the top of the pit, high-density sludge progressively builds up at the base of pits and becomes increasing difficult to remove (Schaub-Jones, 2011). The emptying process is further hampered by the presence of non-biodegradable waste in the pit latrine, particularly if it is to be emptied by pumping.

In Africa, the emptying of pit latrines is usually done by private contractors, but some utilities play an active role in this as part of their responsibility to ensure sanitation for all. In Durban, South Africa, the eThekwini Water and Sanitation (EWS) utility reports that it is very common for the blockages of the suction hose to occur during emptying of pit latrines.[22] eThekwini has developed a system that compacts the pit latrine sludge, dries it using medium-wave infrared radiation, and compresses it into pellets for use in agriculture as a fertilizer. The solid waste (including large quantities of menstrual waste, particularly rags and sanitary pads) are removed mechanically, as shown in the Figures 15 and 16.

Rags are clearly visible in Figure 15, and pads are clearly visible in Figure 16. Few utilities have such mechanized facilities for sludge screening; thus, the solid waste present in the sludge would render it unusable.

Ugu District Municipality in South Africa records few occurrences of blockages during pit emptying, but indicates that a high presence of menstrual management products or other solid waste in pit latrines makes it difficult and time-consuming to liquidize the material prior to suction. When the desludging suction hose gets blocked, the suction operator must stop the work and rod the hose to unblock it, and this adds some time to the emptying process, reducing the number of pit latrines or septic tanks that can be emptied per day.[23]

Lusaka Water and Sewerage Company in Zambia reports that blockages occur in 80 per cent of pit emptying jobs, costing the company an additional 4-5 worker-hours per day, at a monetary cost of USD 335 per day. The blockages are mostly caused by excessive quantities of solid waste in the pits, accumulation of sand in the pit, as most of them are not lined, and hardening of sludge in pits. Menstrual products contribute to 25 per cent of blockages of the suction system.[24]

Some evidence of a problematic practice was found in a report from Kenya: ‘‘…we use pieces of old cloth material instead since modern towels are expensive. After use, it is wrapped in polythene bag and dumped in a pit latrine,’’ (ITDG, 2005). Wrapping menstrual management products in plastic before disposal prevents them from decomposing and poses problems with pit emptying.

In South Asia, on-site sanitation is the norm and nearly every pit and septic tank needs to be emptied. In the region, emptying of septic tanks and pit latrines is done by hand by women. This work is usually done by casteless people rendered untouchable by others, working and living in very poor physical and social conditions. In India it is estimated that over 1.5

[20] Personal communication (telephone and email): B. Torondel, London School of Hygiene and Tropical Medicine

[21] V. Poclava, ServiMASTER, interviewed by M.C. Arteaga, Fundacion Agua Tuya, 2011/07/11

[22] Personal communication (email): N. Macleod, eThekwini Water and Sanitation

[23] Personal communication (telephone and email): P. Mayeza, Ugu District Municipality

[24] Personal communication (telephone and email): M. Bukali, Lusaka Water and Sewerage Company

million people are engaged in this work, at great peril to their health. Reported health effects include premature deliveries for pregnant women, miscarriages, skin diseases, water borne diseases and tuberculosis. The women are often subjected to sexual exploitation (IRC and WaterAid, 2008).

A correspondent from Cambodia who assembled a pit emptying system using a centrifugal pump noted the incredible quantity of menstrual management products among other material gathering around the pump head (the filter) and blocking the suction.[25] The process had to be stopped for the filter to be cleaned by hand every few minutes, while the sludge fell back down into the pit.

On-site toilets must be redesigned for menstrual management

Most sanitation programmes do not address the special needs of women and adolescent girls who use latrines to manage menstruation. It is a consideration that has largely been excluded from latrine design and construction (WaterAid, 2009).

An example from Soshanguve, a settlement near Pretoria in South Africa, highlights the problems that arise when women's needs are not considered in the development of sanitation systems. Aqua privy toilets, similar to septic tanks but with a pour-flush instead of a cistern and with the tank directly below the toilet, were installed in the area, in front of the houses and facing the street. According to Mjoli-Mncube, ''One cannot flush sanitary pads down the toilet, and the outdoor toilet lacks the advantage of the privacy of an indoor toilet. The woman must go to the toilet to take off the pad; then she must return to the house to wash it or to burn it. In a culture where menstruation is never mentioned in public or in the company of males, this violation of privacy is felt to be a major indignity. The women believe that menstruation defines their womanhood, and the struggle with the disposal of the pads makes them feel ashamed of a natural physiological process. Soshanguve garbage men tend to scavenge the garbage bins, and if they find a sanitary pad, they belittle the women of the family, as well as spread rumors about the women's lack of self-respect and honor for the men she expects to dispose of her blood. The male garbage collectors have informed the women that the municipality prohibits the disposal of pads in garbage bins. The women never questioned this information and were too embarrassed to raise it with the civic authorities. Some women mentioned that in Winterveld, where they had come from, they could simply throw sanitary pads down the pit latrine,'' (Mjoli-Mncube, 1998).

Figure 15: Pit latrine sludge being loaded into pelletizer, Durban

Figure 16: Solid waste after separation from pit latrine sludge, Durban

It is imperative that latrines are designed and built to be 'women-friendly'; that is, latrines must have the additional space required for washing reusable menstrual management products; space for storing water to use to wash oneself when changing pads or rags, and a platform for washing menstrual management products. An example of progress is in Bangladesh, where WaterAid

[25] Personal communication (email): B. Clouet, GRET

has provided financial support for the construction of women-friendly communal latrines. Initially WaterAid Bangladesh supported separate chambers in community toilets for menstrual management, but later discovered that women prefer the arrangement inside the latrine rather than separate (IRC and WaterAid, 2008). In India, WaterAid has been involved in demonstrating appropriate design of sanitation facilities for effective menstrual hygiene management (Mahon and Fernandes, 2010). It must be noted that it is critically important that the local needs and practices are pin-pointed and discussed in order to make relevant changes to toilet building designs (Shangwa, 2008).

Conclusion relating to on-site systems

There are varying opinions on the degree to which menstrual waste affects on-site sanitation systems, with some practitioners reporting that menstrual waste is a major problem and others claiming that it is mostly biodegradable and thus does not pose a serious threat to the integrity or functioning of the systems. One conclusion may be that the scale of the problem varies from place to place, depending on the most commonly used materials for menstrual management, as well as the predominant means of disposal. This review highlights the need for improved design of on-site sanitation systems, particularly the toilet superstructure, to support better menstrual hygiene. Consultation with women and girls during the design phase of sanitation programmes would help to ensure that their menstrual management needs are properly addressed.

Another need is for better information to help women and girls select safe materials for menstrual management and appropriate disposal methods. Rags not only pose problems to sanitation systems; they may also pose a health risk to users. Because of the taboos surrounding menstrual blood, washed rags must usually be hidden and thus often cannot be properly dried before reuse. It is therefore possible that insects and microbes could settle on the rags and cause infections when the rag is reused (IRC and WaterAid, 2008). The same problem could occur with reusable menstrual pads. Thus, there is a need to identify options that would not pose such risks, and make them available to women and girls.

PRODUCTIVE SANITATION SYSTEMS

Menstrual management seems not to be a major consideration in the design of sanitation systems, but in the case of productive sanitation systems, there are very important user practice specifications; thus, all potential uses of the toilet must be considered. Productive Sanitation (also known as ecological sanitation) is a sustainable, closed-loop cyclic system in which human excreta is treated as a resource. Urine and feces are stored and processed on site and then, if necessary, further processed off site until they are free of disease-causing organisms. The nutrients contained in the excreta are then recycled by applying the excreta to farmland (Winblad and Simpson-Hébert, 2004). The nutrients nourish the food crops which are then consumed and excreted, thus repeating the cycle.

The distinguishing feature of productive sanitation systems is that they are designed with the intention of using the excreta in agriculture. Thus, in most systems, the urine and feces are kept separate. Urine, which has high phosphorus content and is almost sterile if excreted by healthy humans, can be applied to fields after one month of storage (Richert et al, 2010). Fecal matter, once stored for approximately one year, dries out and becomes safer to handle. It can be further treated by high-temperature composting to ensure that pathogens die off (Winblad and Simpson-Hébert, 2004), and then applied to farmland.

A common type of productive sanitation system is the double-vault urine-diverting dry toilet. The users use one toilet vault until it fills up and then switch to the other one. When the second pit fills up, the first one is ready to be emptied. The urine is diverted into a storage tank that can be emptied periodically, allowing the urine to be captured uncontaminated and potentially used in agriculture.

Another type of productive sanitation system is the biogas decentralized wastewater treatment system (biogas DEWATS), in which ordinary mixed wastewater is digested anaerobically to produce biogas, and the nutrient-rich effluent is treated biologically, before it is applied to farmland (WIN-SA, 2011).

The impact of menstrual waste on productive sanitation systems has yet to be investigated scientifically. This chapter is therefore based on anecdotes from practitioners in developing countries.

Impacts of menstrual management and on the usability of excreta

Menstrual waste present in urine-diverting dry toilets does not pose a problem in emptying them, as this is done manually, but may pose problems in using the excreta for agricultural purposes. Some productive sanitation system operators report that blood in urine is a problem as it affects the color of the urine, causing the potential users to regard the discolored urine as contaminated and unsuitable for use. In Lusaka,

Zambia, it is reported that women are advised to use only the feces hole for both urine and feces during their menstrual period, to prevent menstrual blood from entering the urine tank. Urine containing blood would be unacceptable to the community for cultural reasons, and people would be unwilling to use it for fear that it might be harmful to their health.[26]

Furthermore, according to an international specialist in on-site sanitation, composting of toilet sludge is less successful if the sludge contains solid waste such as undegraded menstrual management products.[27] The solid waste prevents proper aeration of the composting heap and thus hampers the breakdown of the material into sanitized compost. Thermophilic composting, the rapid breakdown of organic material and destruction of pathogens by aerobic bacteria at high temperatures, has been proposed as a possible solution to this problem, as practitioners have found that only the plastic inlay of the pad remains after composting for 90 days; but there are concerns around the difficulty of achieving the optimum conditions for this process to work successfully.[28] To achieve temperatures high enough for thermophilic bacteria to decompose the sludge, and to ensure uniformity of temperature throughout the material, the compost must be kept in a well-insulated, closed container. Otherwise, some of the pathogens in the compost might not be deactivated (Elving, 2009). The process also requires maintaining a moisture content of around 50 per cent, and periodic aeration of the material.[29]

Other operators claim that menstrual management does not pose any major problem to productive sanitation systems. An SEI researcher interviewed the agent at an eco-station (collection point for urine and feces from urine-diverting toilets) in Ouagadougou, Burkina Faso, as well as the municipal official in charge of the city's productive sanitation systems, in May 2011. Both respondents indicated that it was not common that the quality of the collected urine and feces was affected by menstrual or other waste. According to the eco-station agent, there was generally not much solid waste in the chambers. Sometimes there was some toilet paper and condoms, and some pieces of fabric as well, perhaps 0-5 pieces. Solid waste was removed and burned before the compost was put in bags, for distribution to farmers. Thus, menstrual waste was not perceived as a major problem. Probably the women reused fabric pieces many times before they throw them away, and everyone seemed to throw them in the pit latrines, not in the urine-diverting toilets. Blood in the urine had not been experienced as a problem either.[30] Figure 17 below shows dried fecal matter recently removed from a urine-diverting toilet in Ouagadougou. A rag, which had perhaps been used for menstrual absorption, is visible near the middle of the picture.

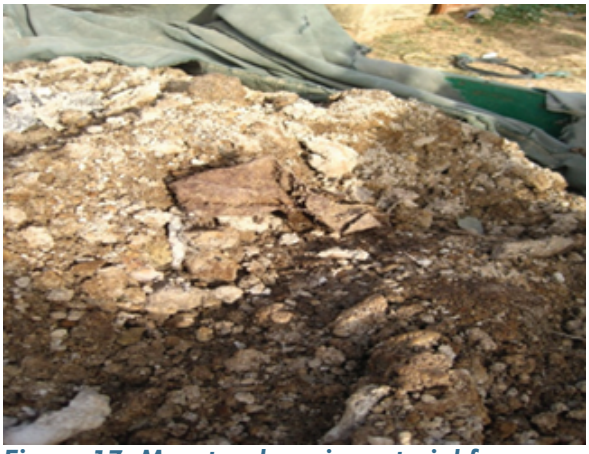

Figure 17: Menstrual rag in material from UDDT chamber

Similar findings were reported by a researcher who visited a productive sanitation scheme in Hanoi, Vietnam. No menstrual products or rags were found in the material recovered from the urine-diverting toilets.[30]

However, in Nepal, concern has been expressed by some communities about disposing of menstrual blood in urine-diverting toilets, as it was felt that this would pose a challenge for the reuse of urine as fertilizer (IRC and WaterAid, 2008). In response to such concerns, a fact sheet published by the NGO Women in Europe for a Common Future states the following: ''during a woman's menstrual cycle, blood will inevitably enter the urine and feces chambers when she is using the dry urine-diverting toilet. However, this organic material poses no threat to the sanitizing or composting process in either the urine or feces chamber nor to its future use as agricultural fertilizer or compost,'' (WECF, 2009). It is uncertain whether this statement is based

26 Personal communication (telephone and email): M. Bukali, Lusaka Water and Sewerage Company

27 Personal communication (telephone and email): E. Huba, sanitation specialist

28 Personal communication (telephone and email): R. Higgins, ecological and agricultural consultant

29 Personal communication (telephone and email): R. Higgins, ecological and agricultural consultant

30 Personal communication (telephone and email): B. Torondel, London School of Hygiene and Tropical Medicine

on scientific research, but several sanitation specialists are of a similar opinion.

In a 2005 e-discussion on the issue of menstrual blood in urine intended for agricultural use, a sanitation specialist from East Africa stated the following, ''menstrual blood either in the main vault or into the urine collection tank is not a problem from a microbiological point of view. The problem arises only from the point of view that the users feel unsure about what to do and where to put their menstrual pads when they change them. In girls' toilets there should be some paper for wrapping menstrual management products and a waste disposal can. The bins could then be emptied periodically and then menstrual management products burned." Another specialist added: "If the girls are worried that the blood being diverted with the urine will show in the collection tank, they need not be. Urine collected during menstruation shows in transparent plastic containers (reddish color to the urine), but once it is put into a colored high-density plastic container (similar to the ones normally used for urine collection) it is impossible to see any trace of the menstruation blood anymore. Hygiene tests conducted in order to formulate the hygienic recommendations on urine use were done on urine produced by both men and women, where the women were using the toilets even during menstruation. So there is no problem with menstruation blood in urine from a health point of view."[31]

According to Håkan Jonsson, a leading sanitation researcher based at the Swedish University of Agricultural Sciences, the guidelines for handling source separated urine provide enough sanitization even if the urine is contaminated with some feces, and this should be more than enough to achieve safe sanitization also with some minor contamination by blood.[32]

In the biogas DEWATS system, the effluent is in liquid form and contains only dissolved materials. As the retention time of the sludge in the digester is quite long, the biodegradable contents of menstrual products are decomposed. Any non-biodegradable materials accumulate in the digester tank, which may only need to be emptied after several years. Thus, menstrual waste does not pose a major problem to the functioning of biogas DEWATS systems.[33] However, it sometimes happens that menstrual products flushed down the toilet or thrown down the manhole get trapped in the inlet to the digester, and block it.[34]

The effects of productive sanitation systems on menstrual management

Urine-diverting dry toilets constructed at schools in Uganda have had a positive impact on female students' menstrual management. Girls at schools with UDDTs are more comfortable to go to the toilet because the UDDTs are clean and do not smell. However, during menstruation, girls often revert to using traditional pit latrines. This may decrease the yield of fecal matter from the UDDTs, as evidenced from Namilyango High School, where the yield of feces was less than predicted because girls did not using the facility when menstruating as they could not dispose of their sanitary towels in the UDDT and thus opted to use a pit latrine instead (SEI and NETWAS, 2011).

Another challenge with the use of UDDTs by menstruating women and girls is that they need water to wash themselves when changing their menstrual management products, but the UDDT system is designed to avoid the use of water. Having extra water in the feces vault slows down the drying of the material.

Conclusion on productive sanitation systems

The consensus seems to be that reusability of feces and urine is not adversely affected by menstrual blood, but that there may be social issues preventing the use of urine discolored by traces of menstrual blood. It is also clear that menstrual management products should not be disposed of in urine-diverting toilets, since they are not easily biodegradable, and even less so in the low-moisture environment of the dry toilet. But, depending on the design of the toilet, using dry toilets may be a challenge for menstruating women and girls, as they need to use water to wash themselves but have to be careful not to let water enter the feces chamber. Thus, a recommendation might be that the toilet design allows for washing water to enter the urine tank but not the feces chamber.

There is generally a higher level of user education for productive sanitation systems than for conventional ones, because of their very specific user practice requirements. This may explain why menstrual management products are not commonly found in these systems. This re-emphasizes the need for clear information for women and girls on how their menstrual absorption materials and disposal practices affect their

[31] EcoSanRes discussion group archives

[32] Personal communication (telephone and email): H. Jonsson, Swedish University of Agricultural Sciences

[33] Personal communication (telephone and email): E. Huba, sanitation specialist

[34] Personal communication (telephone): M. Lebofa, Technologies for Economic Development

sanitation system, as this may a way to ensure that sanitation systems are not adversely affected by inappropriate menstrual waste disposal.

MENSTRUAL WASTE DISPOSAL THROUGH THE SOLID WASTE SYSTEM

As indicated earlier in this chapter, disposal of menstrual waste via the solid waste stream is preferable to disposing of it via the sanitation system. However, the issue of disposal of menstrual waste is absent from waste management training and infrastructure design. Menstrual management is missing from literature be it technical manuals on system design or even simple training modules for health and sanitary workers (Bharadwaj and Patkar, 2004). This review has indeed found a lack of literature on this subject.

In 2004, over 12 billion pads and tampons were disposed of globally (Bharadwaj and Patkar, 2004), most ending up in sanitation systems and landfills. With the growing global population and increasing levels of wealth and literacy in developing countries, it is likely that this figure has increased significantly. While menstrual hygiene has received increasing attention in recent years, particularly in southern Africa and south Asia, disposal of used menstrual absorption materials remains an unsolved problem.

Women that are able to afford disposable menstrual products are likely to use 15,000 sanitary pads or tampons over their reproductive years. An average woman throws away 125 to 150 kg of tampons, pads and applicators in her lifetime. The great majority of these end up in landfills (Bharadwaj and Patkar, 2004), much of this material having passed through sanitation systems as the point of disposal by the user.

In the past, menstrual absorption materials were mainly disposed of by the user by burying or burning them, and this is still common in rural areas. In urban areas, with the proliferation of disposable menstrual management products and centralized solid waste management systems, the disposal of menstrual waste through the solid waste stream is the recommended practice (Ashley et al, 2005), at least in developed countries. The purpose of this chapter is to ascertain to what extent this is the practice in developing countries.

Menstrual waste disposal at home

At home, menstrual waste is disposed of by burning it, burying it, throwing it in a bin or pit latrine or flushing it down the toilet. A report from South Africa indicates that women from different backgrounds tend to dispose of menstrual waste in different ways, depending on their present location. “Women dispose of sanitary products differently depending or where they are at the time. For instance, their behavior when they are at home is different than when they are in public places. When in public places, the behavior of rural people who are accustomed to throwing products in the pit, changes according to the toilet type used. For instance, when they are in a place using flush toilets, they flush the products in the toilet. When it does not flush, they take it out, wrap it with toilet paper and throw it in the bin inside the toilet [cubicle]. There are those who also say that they wrap it and carry it home with them and dispose it in their pit toilets. In the suburbs and formal townships the common behavior seems to be throwing them in the bin or flushing them down the toilet and sometimes it gets burned when at home,”(Molefe and Appleton, 2001).

Because of the taboos surrounding menstruation, menstrual waste must often be managed by women, even where there are solid waste management systems, as these are mostly operated by men (Mjoli-Mncube, 1999).

In a survey conducted in New Zealand, 73 per cent of all respondents indicated that they disposed of menstrual pads and panty liners in rubbish bins when at home, and the remaining 27 per cent burned them (Lynch, 1996). By contrast, 80 per cent of the respondents flushed tampons down the toilet, whether at home, school or work.

Menstrual waste disposal in schools

Menstrual waste seems to be a problematic but largely ignored issue in schools in developing countries. To cite an example, a menstrual hygiene management research student in Lilongwe, Malawi, reports having found not a single bin for menstrual waste in the six schools she had visited thus far. At one boarding school, girls throw their pads into an open pit, which is set on fire with kerosene once a week by a schoolgirl. But because girls are afraid to go out to the pit at night, pads are spread all around the area and get carried around the school compound by dogs and crows. The smell from the accumulating pads and from the burning is a problem, as well as the health risks associated with menstrual material lying around.[35]

An NGO manager from Maseru, Lesotho, reports a similar situation. In her organization’s work in schools, they have found a lack of disposal facilities for men-

[35] Personal communication (email): S. Piper, Cranfield University MSc student;

strual waste. Used menstrual pads are found all over the school compounds, blown about by the wind and carried around by dogs. Some girls stay away from school during menstruation for fear of having to use the dirty toilets, which lack privacy or even hand-washing facilities. The organization has sought funding for a project to build model toilets at selected schools with proper facilities for menstrual management and hand-washing, which the country's Ministry of Education could replicate in all newly-constructed schools.[36].

From the author's own experience in Zambia, in secondary schools, girls' toilet blocks are equipped with plastic bins, with a lid but without a liner, that are emptied weekly by a school janitor and burned within the school's premises.

The Sulabh International Social Service Organization in India has a School Sanitation Club that promotes improved sanitation in schools. Their findings from working in several schools across five states in India as well as in Nepal are that there are generally no bins for disposal of menstrual waste at schools. Girls often have no choice but to flush pads down the toilet or throw them out of the window. In the rural areas, where most girls have no knowledge of pads and would not be able to afford them anyway, girls use rags cut from old bed sheets and saris, and often do not go to school at all for the first three days of their menstrual cycle, because at school there are no facilities for them to wash their rags, and because they are afraid of the shame of staining their clothes. To address these problems, Sulabh is developing a programme to install sanitary napkin vending machines at schools, from which girls will be able to buy napkins at a cost of two rupees (about USD 0.04) each. These low-cost napkins are produced by Sulabh in a recently constructed small-scale manufacturing facility. The organization is also piloting construction of simple incinerators at schools. In the schools where such facilities exist, the girls complain about the smoke and the smell from the incinerators, but this is currently the best possible alternative available to them.[37]

WaterAid is also working to improve school sanitation and menstrual hygiene management in India. At schools, WaterAid India has influenced and supported district governments to provide separate latrines for girls and boys in schools and to ensure water supply is also available. Menstrual waste disposal units with incinerators have been built into the girls' toilets at some schools (Mahon and Fernandes, 2010).

Menstrual waste disposal in community ablution blocks

Community ablution blocks (also called sanitation blocks) provide a community with a central point for toilets, showers and sometimes laundry sinks. The construction of community ablution blocks in informal settlements has become common in developing countries, to rid such communities of the cross-contamination of water supplies from inappropriately sited or incorrectly built pit latrines, as well as other associated health hazards, such as odor and fly-breeding. But, according to a report from Nairobi, Kenya, menstrual management is often overlooked. "An issue that was not foreseen in the planning of sanitation blocks in informal settlements in Nairobi was the disposal of materials for sanitary materials by women. In the absence of other places to dispose of these, they often throw them in the toilet, thus blocking the pipes," (ITDG, 2005).

Menstrual waste disposal in public restrooms and commercial establishments

All respondents interviewed for this study indicated that bins for menstrual waste in public restrooms are a rarity. A sanitation specialist who has worked all over the world reports that in her travels in Africa, Asia, Europe and Latin America, she has rarely found bins for menstrual waste in public toilets. In the relatively few places where bins are found, they often either have no lid or the mechanism for opening the lid is damaged.[38].

For instance, in Lusaka, Zambia, only up-market office buildings and shopping centers have special bins for menstrual waste (with a swing-top or foot pedal) that have a plastic lining and are emptied periodically by a hygiene services company. Public toilets in city centers, bus or train stations generally do not have bins for menstrual products. It seems that disposal of menstrual waste though the solid waste stream occurs only where there are flush toilets; otherwise, disposal in the pit latrine is the preferred option.

Another example is from Cochabamba, Bolivia, where the owner of a hygiene company that services the city's largest shopping mall reported that the women's toilet cubicles all had bins with lids and plastic liners; however, a visit by the interviewer to the mall revealed that the bins had neither lids nor liners.[39]

[36] Personal communication (telephone): M. Lebofa, Technologies for Economic Development

[37] Personal communication (telephone and email): R.R. Choudhury and S. Das, Sulabh International Social Service Organization

[38] Personal communication (telephone and email): E. Huba, sanitation specialist

[39] Personal communication (email): M. C. Arteaga, Fundacion Agua Tuya

In the afore-mentioned New Zealand study, 33 per cent of the respondents indicated that where sani-bins of any description were available in toilet cubicles specifically for menstrual waste, these were the principal disposal method used (Lynch, 1996).

Problems with menstrual waste disposal are global in their distribution. An article from the United States quotes an executive of Cannon Hygiene Inc., a global restroom hygiene service company, who stated, "Although most cleaning workers wear gloves while performing their duties, it is still not uncommon to see workers not wearing protective clothing. Most public restrooms still have the 'swing top' bins for feminine hygiene products that have been used for decades. Often these do not have liners so the cleaning worker must pick them up to empty their contents, often reaching into the container to remove some of the napkins. The problem with this practice, especially if gloves are not worn, is not only that the napkins may pose a health risk, but the lid of the bin becomes soiled and often contaminated with potential blood-borne pathogens. This could prove harmful to the worker, and to subsequent users of the dispensers, as well. Furthermore, menstrual management products might accumulate in regular waste receptacles for several days. Often it is only after an odor problem starts to develop that they are finally emptied," (Shoemaker, 2008).

According to the websites of hygiene services companies, menstrual waste is either incinerated or disposed of in landfills. Kwakuhle Hygiene, a South African hygiene service company, claims that "the Sanibins are serviced by our staff according to their clients' requirements on either a 7-day or 14-day service cycle. The Sanibin sanitary waste is then taken for either landfill or incineration." Initial Washroom Solutions, part of the internationally-recognized Rentokil Group, reports that the sanitary waste collected from bins serviced by their company is disposed of at landfill sites. This is in support of the company's view that incineration plants are an expensive and wasteful solution that actually damages the environment more than protects it.

Emptying practices vary, with some hygiene companies lining the bins with plastic liners for easy emptying, and others avoiding the use of lining and instead periodically replacing filled bins with empty, sterilized ones.

CONCLUSION

Disposal of menstrual waste require the presence of covered waste bins or containers, which are emptied and cleaned on a regular basis, located in a place that offers privacy (Tjon a Ten, 2007), preferably within the toilet cubicle. It has proved difficult to determine how common it is for there to be bins in women's and girls' ablution facilities. It seems that the issue of disposal of menstrual waste has been largely ignored, particularly in developing countries. This may be due to the fact that sanitation programmes and systems are mostly designed and managed by men, who may not be sensitive to problems that do not directly affect them. It may also be due to the fact that discussion of menstruation and related issues remains taboo in many cultures. These taboos must be overcome if any progress is to be made in improving the wellbeing of women and girls during menstruation.

This review highlights the need for women's involvement in all aspects of sanitation planning and service delivery. It also underlines the need for better solutions that reduce the amounts of menstrual waste that must be disposed of. If menstrual waste is to be disposed

Bins for menstrual waste

of via the solid waste stream, this needs to be done in a manner that protects the privacy and wellbeing of menstruating women and girls, and the health of the workers that come into contact with the waste.

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3. FRAMEWORK OF INTERACTIONS BETWEEN SANITATION SYSTEMS AND MENSTRUAL MANAGEMENT

By Marianne Kjellén, Chibesa Pensulo and Nelson Ekane

This chapter discusses the interaction between sanitation systems and menstrual management and should serve as a framework for the further exploration of this interrelationship. It starts with a brief conceptualization of sanitation systems with their technological and social underpinnings, as well as an outline of sanitation system-related decision-making at various levels. The final section provides a matrix of the interactions of menstruation management issues with various points in the sanitation system.

CONCEPTUALIZATION OF THE SANITATION SYSTEM

"Sanitation" as used in the International Year of Sanitation communications, refers to "the collection, transport, treatment and disposal or reuse of human excreta, domestic waste water and solid waste, and associated hygiene promotion" (de Albuquerque, 2009, p. 6). In the same context, "basic sanitation" has been defined as "the disposal of human excreta to prevent disease and safeguard privacy and dignity" (Evans *et al.*, 2009, p. 6). The World Health Organization refers to sanitation as "the provision of facilities and services for the safe disposal of human urine and feces" but would generally also include "the maintenance of hygienic conditions, through services such as garbage collection and wastewater disposal." (World Health Organization, no date).

The disposal of feces stands out as the central part of these definitions, though always as part of a whole system of physical infrastructures and social practices. The weight that the basic sanitation definition above gives to 'privacy and dignity' points at the importance of the adequate service to the user, including women and girls at times of menstruation. As discussed in the previous chapter, the needs of menstruating women and girls are remarkably absent in sanitation planning and system design, although clearly an issue when it comes to dealing (or not dealing) with the disposal of menstruation-related waste products.

Emphasizing the reciprocal interrelationship between technology and society, sanitation systems may be understood as so-called socio-technical (infrastructure) systems. These consist of artefacts (hardware or physical infrastructure) which through human agency and social structures and organizations fulfill the functions of the systems (Geels, 2005). This software side of the system is composed of knowledge and cultural meaning as well as labor and markets and their regulation (rules and norms). Geels (2004) distinguishes between the production, distribution and use of the artefacts of the system, see figure below, with their distinctive internal logics and evolution but interrelated regulation and cultural embedment in society.

Thus, sanitation systems include more than just the physical infrastructure; they include the practices of the people who use, maintain and govern them. In relation to the sanitation system and menstruation management interaction, the production domain and its knowledge and perceptions is crucial for the evolution of systems, its design choices and the inclusion or (which is generally the case) the exclusion of menstrual management considerations. For the present framework of the interaction, however, the focus lies on the application (technology-in-use) domain – the use of the system – and to some extent also the so-called distribution – in the case of sanitation being the conveyance infrastructure of the treatment/disposal procedures.

Further, the construction, operation and maintenance as well as the use of sanitation systems are governed by decisions made in different domains, ranging from the individual and household levels to neighborhood/ward/district and the level of the city and beyond (Evans *et al.*, 2008), including also national and international levels.

Decisions relating to the investment, construction and operations of sanitation systems are often taken at the city level, and often guided by national or even international regulations. By-laws and operational practice may be adopted at the ward or district to tally with local circumstances, with informal adaptations to the system taking place at neighborhood and household levels. User practices may be guided by national education systems and even international hygiene campaigns, though socialization of sanitation and hygiene habits generally takes place within the household. With most of the world's toilets being private bathrooms, the furnishing and investments into this facility is largely a family business. Decisions about how to dispose of household resources are gendered, with men and women having different interests and spheres of influence within the household, and their interests also change over time (Evans *et al.*, 2008)

Ultimately, however, sanitation system users are individuals, who often act alone in their decision on how to actually use the system and dispose of the anal cleansing and potential menstrual blood absorption material.

The next section discusses the interaction with the sanitation system – mainly its physical features – and menstrual management practices – from the perspective of the user.

SANITATION SYSTEM AND MENSTRUAL MANAGEMENT INTERACTIONS

The thrust of the sanitation system and menstruation management interactions, i.e. how the behavior or menstruating women and girls is conditioned by the sanitation systems and conversely, how the functioning of the sanitation system is affected by the behaviors and disposal methods of its users, occur at the use of the toilet.

A full range of issues related to this interface between 'users' and 'systems' at the toilet are listed in Table 5, which deals with the design and furnishing of the actual room or place for defecation. The state of repair, maintenance of cleanliness, as well as the size of the room and level of convenience with regard to water availability, privacy and security are suggested to impact on menstrual management behaviors and how convenient the system is for menstruating users.[40]

The design and maintenance of the defecation place are considered to be key issues at this point. The type of technology or facility, however, has great impact on the choice of menstrual waste disposal methods. Hence, looking at the further interaction, starting with the actual collection of feces in the toilet, the type of facility is critical.

Table 6 is structured around a range of different technologies (first column) and the so-called 'functional groups' (Tilley *et al.*, 2008) of collection and conveyance heading the second and third columns, with the list of issues relating mostly to how menstrual waste is disposed of in relation to different types of systems in the fourth and final column. The issues of menstrual wastes, either as traces of blood or discarded material for its absorption, are discussed here in relation to privacy of the menstruating woman or girl, as well as their potential to disrupt the proper functioning of the sanitation systems.

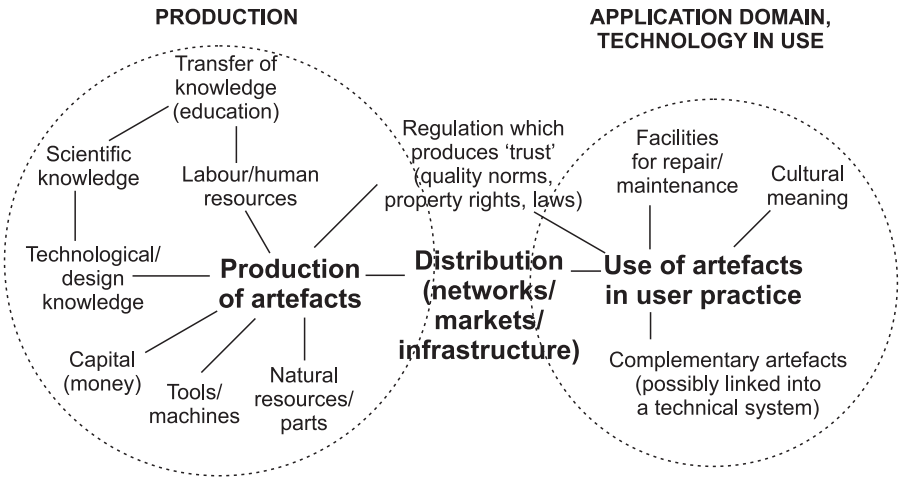

Figure 17 – Basic elements and resources of socio-technical systems, from Geels (2004, p. 900)

[40] Dealing with so-called 'fixed-place defecation' systems, issues of open defecation are not discussed.

Table 5: Sanitation System and Menstrual Management Interaction at the User Interface

Interaction at the User Interface – the toilet space		
SS general feature	**SS specific features**	**Particular relevance to MM**
Location and design of toilet	• Inside/outside of dwelling. • Shelter and structural safety • Space and lighting • Security (feeling of being safe from harassment or embarrassment) • Privacy (feeling of not being heard or seen) • Doors and locks • Amenable for cleaning: smooth/ rough material, shape of toilet seat/ slab / foot steps • Existence and fit of lid (of receptacle/ drop hole)	• Issues and problems of mobility and needs for security and privacy augmented during menstruation. • • Additional room for maneuvering typically required. (e.g. changing in case of menstrual 'accident') • • Public/institutional restrooms – number of cubicles, waiting time, anonymity
Availability of waste bin	• Location (inside / outside of toilet cubicle) • Type – plastic bag, basket, plastic bin • Covered / open • Frequency of emptying	• Existence of waste bin crucial for menstrual waste disposal • Lid impacts visibility of waste bin contents (as well as the ease and safety of access to bin)
Availability of water	• Presence and reliability of supply of water for hand washing, anal cleansing, cleaning (or bring your own) • Piped, running water or bucket/drum • Location of water point (outside / inside toilet and accessibility when squatting / sitting)	• Additional needs for personal hygiene + potential need for washing of multiple use material or clothes (menstrual accidents) • Issue – water availability inside toilet cubicle
Availability of toilet paper	• Presence of toilet paper or similar material for anal cleansing (or bring your own)	• Availability of wrapping material for used menstrual absorption material

Table 6: Sanitation System and Menstrual Management Interaction at Collection and Conveyance

Interaction at Collection and Conveyance			
Type of Toilet	**Collection / Storage / Division into Fractions**	**Conveyance Technology**	**Particular relevance to MM**
In principle, no fecal collection technologies are designed to handle disposed pads, tampons or discarded rags. Principal destinations for used menstrual material being: Waste bin (or, in particular cases local incinerators/fires)			
Pit latrine (traditional or improved) – on-site	All-in-one (feces, urine, cleansing material and menstrual waste) stored permanently or until pit is full	No conveyance until pit is full; then • backfill full pit and construct new one, or • empty the pit - by digging, manually-operated equipment or motorized suction pumps	Used absorption material can be easily and discretely discarded down the pit Menstrual absorption products cause pits to fill up faster[42]
Pan/bucket latrine – on-site[43]	All-in-one - stored until (regular/irregular) collection	Manual collection and (manual/animal/motor driven) conveyance Where treated as 'black water' – should contain only fecal material. Where incinerated, all-inclusive.	Depending on the presence of a lid, menstrual waste may be visible to other users / collectors Menstrual absorption products adds to rapid filling of buckets/pans
Flush – pour-flush / latrine (with water seal)	Designed to collect urine, feces and material that do not obstruct the water seal	Short conveyance through diversion chamber to alternate leach pits. To be abandoned when full.	Menstrual absorption products to go with anal cleansing material into waste bin/collector. Menstrual waste disposed of in toilet likely to cause immediate blockage (and disincentive to throw into toilet)[44]
Flush – pour-flush / small-bore sewered[45]	Designed to collect urine, feces and anal cleansing water. Anal cleansing material and menstrual material destined for waste bin/collector - > solid waste	Water-carried through relatively narrow piping, by gravity flow to local/centralized treatment plant	Menstrual absorption products to go with anal cleansing material into waste bin/collector. Menstrual waste disposed of in toilet likely to cause immediate blockage (and disincentive to throw into toilet)

41 "Non-biodegradable materials, such as stones, glass, plastic, rags, etc., should not be thrown into the pit, as they reduce the effective volume of the pit and hinder mechanical emptying" (Brikké and Bredero, 2008, p. 107).

42 Pan or bucket systems are generally considered to be an unacceptable technology. Nevertheless, it persists in many informal urban areas.

43 "No material that could obstruct the U-trap should be thrown in the pan" (Brikké and Bredero, 2008, p. 115).

44 Small- or large- bore sewer systems may be combined with either pour- or cistern-flush system. Moreover, a malfunctioning cistern-flush may in practice be converted to pour-flush.

Interaction at Collection and Conveyance			
Type of Toilet	**Collection / Storage / Division into Fractions**	**Conveyance Technology**	**Particular relevance to MM**
Flush – cistern-flush / large-bore (conventional)	Designed to collect urine, feces and anal cleansing material. Menstrual material destined for waste bin/collector - > solid waste	Wastewater carried through relatively wide piping, by gravity flow with booster pumping to local/centralized treatment plant	Menstrual absorption products to go into waste bin/collector. Possible to dispose of menstrual waste in toilet, but may contribute to blockages anywhere in system
Urine-diverting dry toilet	Designed to collect urine and feces separately, biodegradable anal cleansing material may be disposed of into feces chamber	Emptied manually after a containment period of 6-12 months[46]	Menstrual absorption materials supposed to go into waste bin/collector. If disposed of in the feces chamber, the materials will pose problems in the composting and use of the excreta as they will not decompose.[47] As water must not enter the feces chamber,[48] washing of self and reusable menstrual materials may be difficult

In the final table (7) the functions of treatment/ disposal/application (reuse) are treated together. The sanitation system – menstrual management interaction here relates to the presence of menstrual waste products that have been disposed together with feces (or whether disposed of through solid waste system).

Where menstrual waste products are visible they are rarely possible to connect to the individual having discarded them. It is hence less of an issue of privacy, but more one of environmental degradation.

45 (Winblad and Simpson-Hébert, 2004, p. 13)

46 Personal communication: Elisabeth-Maria Huba, sanitation specialist, 2001/07/05

47 Wafler and Spuhler, 2010)

Table 7: Sanitation System and Menstrual Management Interaction at Treatment, Disposal, and Potential Reuse

Interaction at Treatment / Disposal, Application (reuse) of Waste / Products.		
Type of system	**Treatment / Disposal / Application (Reuse)**	**Particular relevance to MM**
Pit latrine	Excreta and other organic materials decompose in the pit by aerobic and anaerobic processes	Menstrual products are rarely fully biodegradable, and decompose slowly if at all, thus filling up the latrine faster.
Bucket latrine	Contents are disposed of into a pit latrine or wastewater treatment plant	Contribute to problems in the sanitation system they are emptied into
Urine-diverting dry toilets	Urine contained for at least one month and is then suitable for use in agriculture,[49] feces dry in chamber for 6-12 months and may then be composted, until a total storage time of 1-2 years, depending on local ambient temperatures[50]	Presumably, because the contents of the feces chamber are drier than in a pit latrine, even menstrual materials that might partially decompose in a pit latrine may not decompose at all in a UDDT; thus, they must not be disposed of in the toilet
Flush toilets – sewered, large or small-bore	Treated by biological processes at centralized treatment plants	Some menstrual absorption products slip through the solid waste screens at the sewage treatment plant intake, and end up in rivers, lakes and seashores that the treatment plants discharge into[51]
Flush/pour-flush to septic tank	Excreta and wastewater are treated anaerobically in the tank, septage may be discharged into a wastewater treatment plant after tank is emptied, but is often discharged onto fields or into waterways	Same problems as for sewered toilets if septage is disposed of at a wastewater treatment plant; random dispersal of menstrual waste if septage is discharged onto fields or into waterways[52]

48 (Winblad and Simpson-Hébert, 2004, p. 9)

49 (Winblad and Simpson-Hébert, 2004, p. 14)

50 (Water UK, no date)

51 (AECOM International Development Inc. and the Department of Water and Sanitation in Developing Countries (Sandec) at the Swiss Federal Institute of Aquatic Science and Technology (Eawag), 2010, p. 13)

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SEI - Africa
Institute of Resource Assessment
University of Dar es Salaam
P.O. Box 35097, Dar es Salaam
Tanzania
Tel: +255-(0)766079061

SEI - Asia
15th Floor Witthyakit Building
254 Chulalongkorn University
Chulalongkorn Soi 64
Phyathai Road Pathumwan
Bangkok 10330
Thailand
Tel: +(66) 22514415

SEI - Oxford
Suite 193
266 Banbury Road,
Oxford, OX2 7DL
UK
Tel: +44 1865 426316

SEI - Stockholm
Kräftriket 2B
106 91 Stockholm
Sweden
Tel: +46 8 674 7070

SEI - Tallinn
Lai 34, Box 160
EE -10502, Tallinn
Estonia
Tel: +372 6 276 100

SEI - U.S.
11 Curtis Avenue
Somerville, MA 02144
USA
Tel: +1 617 627-3786

SEI - York
University of York
Heslington
York YO10 5DD
UK
Tel: +44 1904 43 2897

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