WATER SUPPLY, SANITATION AND WASTEWATER MANAGEMENT: PROGRESS AND PROSPECTS TOWARDS CLEAN AND HEALTHY SOCIETY

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PROCEEDINGS OF A SYMPOSIUM

Editors

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Preface

Sanitation is not only vital for human health but also generates economic benefits, helps the environment and contributes to dignity and social development. Irrefutably, water, health and sanitation are interrelated. Thus access to adequate and quality water supply is essential for better health and sanitation.

Urban and industrial development not only competes for the finite water resources but also pollutes the water bodies making them unusable for the competing uses including the environment. Therefore, cost effective wastewater management system is a need of the time.

To emphasize these issues, the UN General Assembly declared the year 2008 as the "International Year of Sanitation". Coincidently, water and sanitation (WatSan) has emerged as the number one priority for almost all the local and international NGOs who are working on relief and rehabilitation in Sri Lanka.

Cap-Net Lanka – Capacity building Network in Integrated Water Resources Management (IWRM), as a country partner of global Cap-Net (www.capnet.org) is mandated to impart new knowledge and disseminate the knowledge generated by the local institutions and individuals in the field of IWRM in Sri Lanka. As such, this symposium on "Water supply, sanitation and wastewater management" is the second in the series of dissemination activities that Cap-Net Lanka intents to continue annually.

The objective of the symposium was to provide a forum for the researchers and practitioners to share and discuss their knowledge and experiences in the field of water and sanitation in Sri Lanka for the benefit of others.

The symposium attracted more than seventy-five participants from various government and non-government organisations. Altogether, eleven papers covering the areas of groundwater pollution, wastewater treatment, wastewater management and water supply & sanitation were presented and discussed.

On behalf of the Cap-Net Lanka, I extend my gratitude to the Postgraduate Institute of Agriculture (PGIA), Peradeniya for co-sponsoring symposium. We are thankful to the Chief Guest - Prof. Arjuna Aluwihare, Former President, National Academy of Sciences of Sri Lanka and Guest Speakers - Prof. Athula Perera, Director, Postgraduate Institute of Agriculture, Peradeniya and Prof. C. Sivayoganathan, Acting Dean, Faculty of Agriculture, University of Peradeniya for accepting our invitation.

I extend my gratitude to Prof. C. Sivayoganathan (Head, Department of Agric. Extension), Prof. R.P.De Silva (Head, Department of Agric. Engineering), Prof. E.I.L. Silva (IFS, Kandy), Dr. Ananda Jayasinghe (Head,

Department of Community Medicine) and Dr. M.I.M. Mowjood (National Coordinator, Cap-Net Lanka) for chairing the sessions.

I appreciate the service rendered by the reviewers who helped to improve the quality of the proceedings substantially. The support extended by the academic and academic-support staff members of the Department of Agricultural Engineering, Faculty of Agriculture, University of Peradeniya and the students of the PGIA are greatly appreciated. My special thanks go to Ms. Chathurika Galahitiyawa, Administrative Secretary, Cap-Net Lanka for all the logistic arrangements. Finally, I thank the symposium participants who actually made this event a success through their active participation.

S. Pathmarajah
Symposium Coordinator / Editor

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Status of water supply wells in Jaffna Peninsula

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Abstract

Good quality drinking water is of primary importance for human health and well being since more than 80% of the diseases that affect humankind are water-borne. In Jaffna Peninsula, groundwater is the only source of water for drinking and domestic purposes. Toxic chemicals are being found in drinking water supplies and they may be poising unacceptable human health risks for the people in the area. Karaveddy, Valvettithurai, Karainagar, Velanai, Kayts sump, Araly, Vaddukoddai, Chunnakam and Puttur water supply wells were tested for all physical, most of the importance chemical and bacteriological characters during January to December 2007 and compared with Sri Lankan drinking water standards. The analyses were made based on the Sri Lankan standards. Out of tested wells, water supply wells at Velanai, Puttur, Chunnakam, Valvettithurai and Kayts sump did not have water quality problem and can be used continuously for human consumption with monitoring. Water supply wells at Karainagar and Vaddukoddai were below permissible level of all physical and bacteriological properties except for some chemical properties during few months of the year. Hence, extraction of water from above water supply wells could be extended but continuous monitoring of chemical characters is essential. Karaveddy and Araly wells are not suitable for drinking purpose because most of the chemical and physical characters of these wells exceed the Sri Lankan standard levels. Hence, installation of purification plant or identification of a new supply source is very essential at Araly. At Karaveddy, operation of reverse osmosis plant is recommended.

Introduction

Good quality drinking water is of primary importance for human health and well being. Groundwater constitutes 97% of global freshwater and is an important source of drinking water in many regions of the world. The estimated groundwater potential of Sri Lanka is 780,000 hectare meters per annum. The demand for water in Sri Lanka is steadily increasing, particularly for urban/rural water supplies, irrigated agriculture and in the industrial sector. This rapid increase in demand is exerting a considerable pressure on the available groundwater resources (Panabokke and Perera, 2005).

In the Jaffna Peninsula, groundwater is used not only for drinking and domestic purposes but also for agricultural purposes. The most intensively exploited areas are the urban areas of Jaffna, Chavakachcheri and Point Pedro, and to a lesser extent is Valvettithurai which lies to the west of Point Pedro. For rural water use, the most heavily exploited areas are in Valikamam East and a small zone in Valikamam West (Punthakey and Nimal, 2006). Over extraction has lead to a widespread increase of salinity, which has been the main focus of groundwater resource management in the past years (Kraft, 2002).

More than 80% of diseases that affect humankind are water-borne. Water-related disease remains one of the major health concerns in the world. Groundwater is widely used for drinking water, toxic chemicals are being found in drinking water supplies and they may be poising unacceptable human health risks (Schmoll *et al.*, 2006). A national consultant to the WHO (Sivarajah, 2003) declared that "the high nitrate content in water could be related to the high prevalence of cancer of the gastrointestinal tract in the people of Jaffna".

Masarik (2007) said chemicals that are toxic and might be found in drinking water may cause either acute or chronic health effects. Evidence relating chronic human health effects to specific drinking water contaminants is very limited. The microbiological quality of drinking water is the most important aspect of drinking water because of its association with waterborne diseases. Millions of people in the world die every year from water borne diseases such as cholera, typhoid and bowel diseases and faecal contamination of drinking water is responsible for hepatitis and amoebic dysentery (Ileperuma, 2000). Total coliform can be used as an indicator of treatment effectiveness and to assess the cleanliness and integrity of distribution systems. E-coli are considered as the most suitable index of faecal contamination (Ayres and Mara, 1996).

Hence, the estimation of water quality of a water supply scheme is imperative to take care of the safety of the population. The objective of this study is estimation of physical, chemical and biological parameters of existing water supply schemes and comparison of these parameters with Sri Lankan standards to recommend them as drinking water supply sources.

Materials and methods

Selection of water supply schemes

Water supply schemes are in operation at the water problematic areas of the Jaffna Peninsula. In this study, nine water supply schemes were selected to obtain water samples for periodic monitoring of water quality such as, Attchuveli, Chunnakam, Karaveddy, Valvettithurai, Vaddukkodai, Araly south, Kayts, Velanai and Karainagar. The tested wells are dug wells except Kayts. The water supply well at Kayts is a sump which receives the water from eight wells at Allaipiddy and after that water is pumped to an overhead tank from the sump. Table 1 shows the quantity of water supplied in October 2007 with total service connection and total number of beneficiaries.

Collection of water samples

Water samples were collected by specific sampler at surface water. Each sample was poured into 1 litre plastic bottles after rinsing several times with the sample water. These bottles were tightly closed and labelled. The collected samples were transported to the laboratory of National Water Supply and Drainage Board (NWS&DB), Jaffna.

Table 1. Quantity of water supplied in October- 2007.

Name of scheme	**Quantity of water supplied-m^3**	**Total service connection**	**Total consumers**
Araly South	730	33	1400
Chunnakam	1385	28	1200
Vaddukoddai	661	22	900
Kayts	1068	87	3500
Velanai	1488	52	2100
Karaveddy	2587	77	3100
Valvettithurai	1132	26	1100
Watharawattai and Attchuvely	1919	43	1800
Karainagar	300	9	400

(Source: Monthly report, National Water Supply and Drainage Board, Jaffna 2007).

Analytical techniques

The physical, chemical and biological parameters were carried out to each sample within 48 hours after collection. The procedure of the analysis was based on Sri Lankan standard 614 (Sri Lanka standard 614: part 1, Part 2 (1983). Table 2 shows the parameters selected for analysis with the method of analysis. All the data were compared with Sri Lankan drinking water standards (SLS) for the recommendation of the water supply for drinking purposes.

Table 2. Drinking water quality parameters and method of analysis.

Parameters	Method	Chemicals used
Turbidity	Turbidity meter	-
Colour	Hazen colour disk & Lovibond comparator	-
Chloride	Mohr's titration	0.02N $AgNO_3$ solution Potassium chromate
Total alkalinity	acid-base titration	0.02N HCl Methyl orange
Total hardness	EDTA titration	0.01N EDTA Eriochrome Black T Ammonium – buffer
Sulfate	Turbidimetric method	Barium chloride Buffer solution
pH	pH meter	-
EC	Electrical Conductivity meter	-
Arsenic	Arsenator	-
NO_3- as N	Colorimetric - Spectrophotometer	-
NO2- as N	Colorimetric - Spectrophotometer	-
Phosphate	Colorimetric - Spectrophotometer	-
Fluoride	Colorimetric - Spectrophotometer	-
Total iron	Colorimetric - Spectrophotometer	-
Manganese	Colorimetric - Spectrophotometer	-
Total coli form	Membrane filtration method	M-Endo broth
E-coli	Membrane filtration method	M-FC broth

Results and discussion

Physical characters

Colour

All water supply wells except the water supply wells at Karaveddy, Kayts and Velanai, colour was 10 Hazen units. In the case of Karaveddy water supply well, colour was ranging between 10-40 Hazen units and Kayts and Velanai, colour was ranging between 10-30 Hazen units. The colour in groundwater may be the result of the presence of natural metallic ions (Iron). Mageswaran (2003) showed that the water samples from Karaveddy were in light brown colour due to iron content. All the water supply wells were within the recommended level of SLS except Karaveddy.

Turbidity

In the present study, maximum turbidity value was observed in Karaveddy water supply well (17.2 NTU) during November. In the case of Kayts sump turbidity was above permissible level (8NTU) during October to December. The turbidity arises due to the suspended solids in the groundwater. Turbidity values were observed as less than 2 NTU in other water supply wells.

Taste and odour

The tested water supply wells for taste and odour were found as unobjectionable except wells at Karaveddy, Vaddukoddai, Karainagar and Araly in which the water tested as slightly salty.

Chemical characters

Chloride content

Chloride is a common non-toxic material present in small amounts in drinking water and produces a detectable salty taste at the aesthetic objective level of 250 mg/l (Ontario drinking water standards, 2006). The chloride values of water supply wells ranged from 50 mg/l to 2000 mg/l during this study period.

Figure 1 shows the average chloride concentration of all water supply wells. All the wells were below the permissible level of 1200 mg/l except Karaveddy. This would be due to the over exploitation of water (Table 1) which results in up corning of salt water into fresh water lens. In addition, runoff water is also received from the surrounding fields, since the water supply well is situated inside an ‘Aththulu’ pond, constructed in centre of low lying areas of paddy fields. Though high chloride concentration was observed in the supply well at Karaveddy, Reverse osmosis plant (RO plant) was established to purify the water for the supply. But the waste water and balance water from RO plant was diverted back to pond where the supply well is present. All these factors are contributing for the high chloride concentration at Karaveddy.

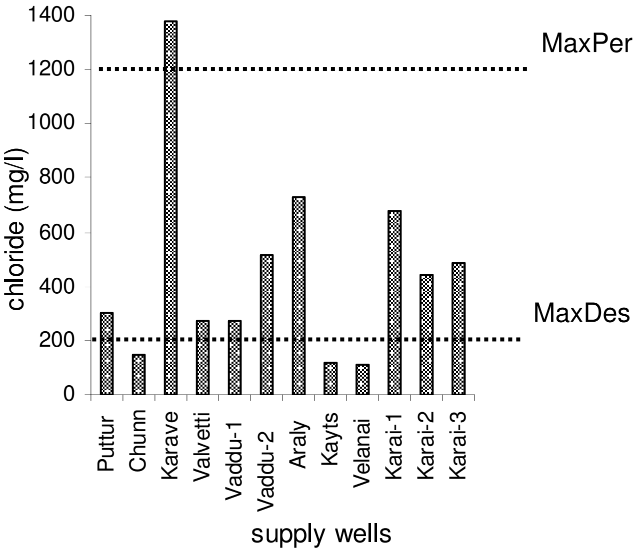

Figure 1: Average chloride of supply wells.

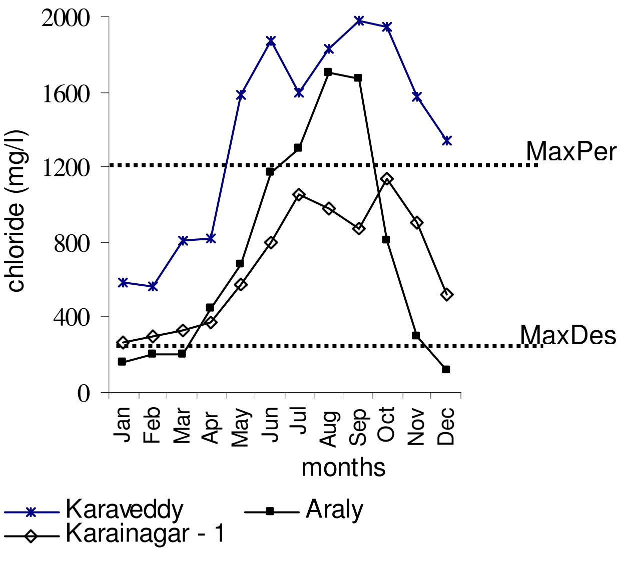

Figure 2: Temporal variation of chloride.

Figure 2 shows temporal fluctuation of chloride concentration at selected water supply wells. Even though average chloride concentration was less than the permissible level of SLS, some of the months values were exceeded the level. The high chloride concentration was observed in dry period. The above phenomena clearly shows the over drafting of water supply from these two (Karaveddy and Araly) supply wells and high evaporation during dry period.

Kraft (2002) mentioned that the increasing level of salinity has been revealed in several studies since 1968 and the levels of chloride generally vary from 50 mg/l up to 4000 mg/l and the level increases up to 30,000 mg/l in Jaffna Peninsula. The permissible level of chloride is 250 mg/l. It has been reported that the salinity levels correlates with the case distribution of patients who suffer from esophageal cancer, when the consumed groundwater contains chloride levels of more than 600ppm (Kraft 2002). However, according to the World Health Organization (WHO, 2006) no health based guideline value is proposed for Chloride in drinking water. However, chloride concentrations in excess of about 250 mg/l can give rise to detectable taste in water. According to the USA Public Welfare Groundwater Quality Standards (2000), the enforcement standard limit is 250 mg/l and the preventive action limit is 125 mg/l. Out of tested nine water supply wells, Araly and Karaveddy had the problem of high Chloride content.

Total alkalinity

The Alkalinity measures the presence of bicarbonate, carbonate or hydroxide constituents. The result revealed that the total alkalinity values of water supply wells varied from 100 mg/l to 1000 mg/l. The average alkalinity value and temporal variations were shown in Figures 3 and 4 respectively.

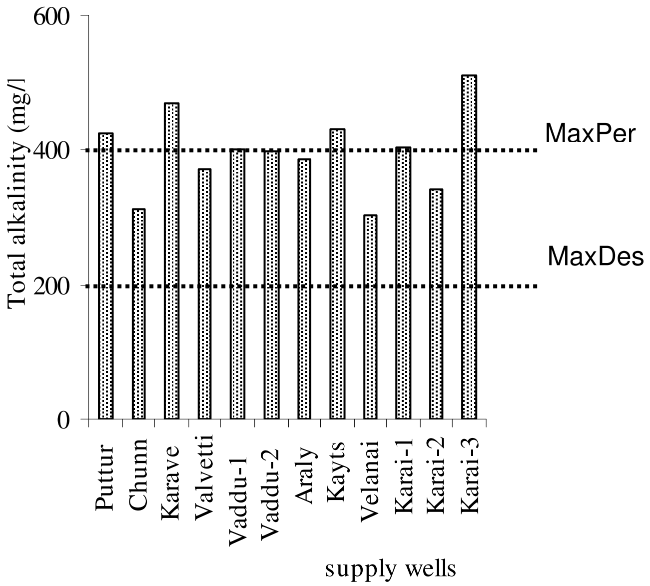

Figure 3: Average total alkalinity of all supply wells.

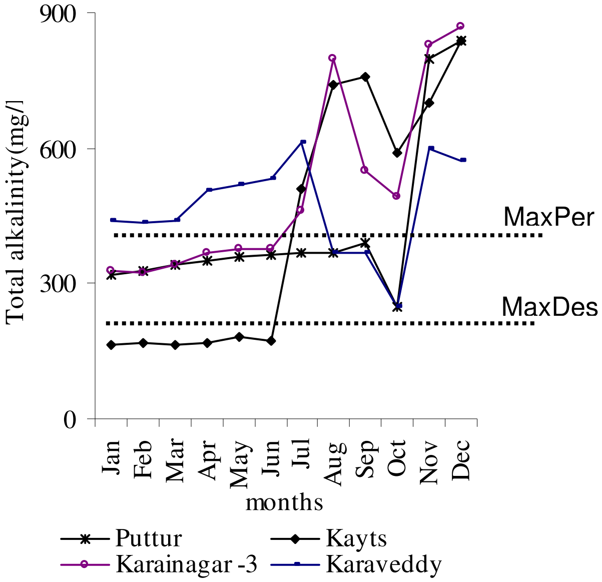

Figure 4: Temporal variation of total alkalinity.

The total alkalinity values of all water supply wells were below maximum permissible level during dry period and above permissible level during wet period. Most of the water supply wells had the peak total alkalinity values during wet period in which relatively a higher proportion of leaching would occur. As a result, the concentration of carbonates, bicarbonates and hydroxides would increase above the standard levels.

Based on the recommendation of SLS, only well at Karainagar (well 2) was satisfying the requirement. All other supply wells were not at the standard for supply during wet season and Araly, Velanai, Vaddukoddai 2, Karainagar 1 & 3 and Kayts wells were not recommended during some of the months in dry season. But Karaveddy (Figure 4) well was not recommended even during driest period.

Highly alkaline waters are unpalatable and may force consumers to seek other water sources. Also, alkalinity levels affect the efficiency of coagulation process (WHO, 2006). Masarik (2007) said high alkalinity water (greater than 150 mg/l) may contribute to scale (lime) build-up in plumbing.

Total hardness

The hardness of water relates to the amount of calcium, magnesium and sometimes iron in the water. Christopher (2006) reported that natural sources of hardness principally are limestone which is dissolved by percolating rainwater made acidic by dissolved carbon dioxide. The total hardness values of water were determined as ranging from 150 mg/l to 1100 mg/l.

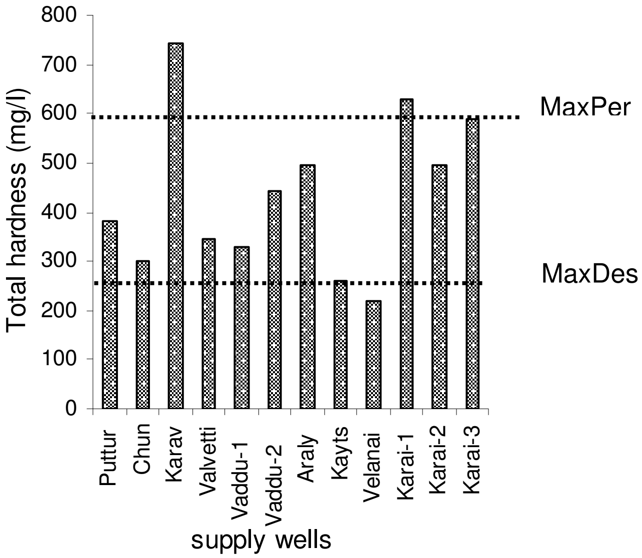

Figure 5: Average hardness values of all supply wells.

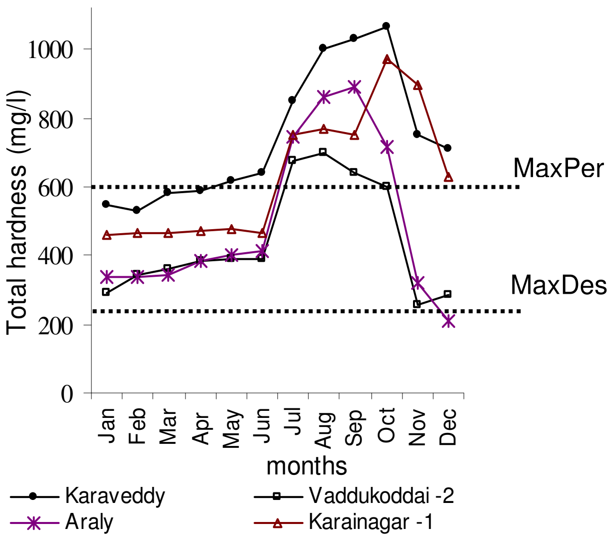

Figure 6: Temporal variation of total hardness at some supply wells.

Based on the average total hardness value (Figure 5), water supply wells at Karaveddy and Karainagar 1 were above maximum permissible level (600 mg/l). But according to the Public Health Groundwater Quality Standards of USA, it is better to start preventive measures when the total hardness is above 300 mg/l in drinking water wells (USEAP, 2000). Maheswaran (2003) mentioned that the Jaffna

Peninsula has the highest levels of total hardness in groundwater due to cumulative effects of the carbonate factors, such as Cl^-, NO_3^- and SO_4^{--}.

A number of ecological and analytical epidemiological studies have shown a statistically significant inverse relationship between hardness of drinking-water and cardiovascular disease. Seneviratne and Gunatilaka (2005) mentioned that hard water is suitable for drinking. But it is showing low rate of heart diseases when compared to soft water. The health effect of drinking hard water may induce the stone formation in kidney due to the presence of calcium.

Sulphate

Jaffna Peninsula water supply wells have the sulphate in the range from 20 mg/l to more than 500 mg/l. In the case of Karaveddy water supply well (Figure 8), concentration of sulphate was below maximum permissible level (400 mg/l) during dry period. However, sulphate concentration was above permissible level and was more than 500 mg/l during wet period. Other water supply wells were below the permissible level in all months of the year except Karaveddy, Araly and Karainagar. Kendall (1992) mentioned that sulphate content in excess of 250 to 500 mg/l may give water a bitter taste and have a laxative effect on individuals not adapted to the water. High levels of sulphate may be associated with calcium, which is a major component of scale in boilers and heat exchangers.

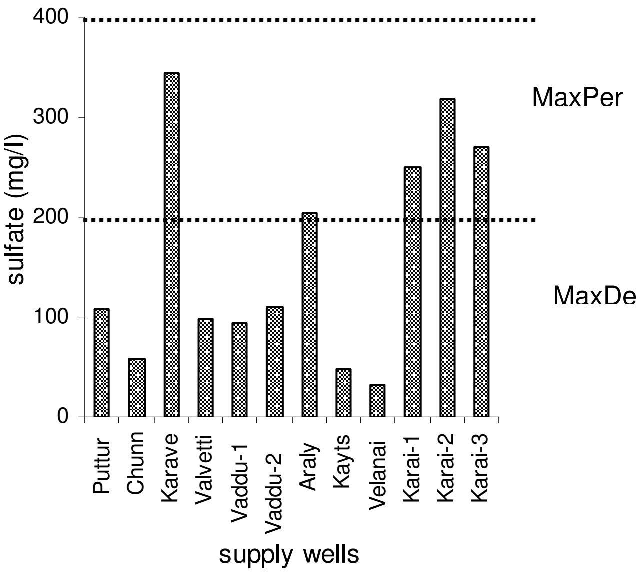

Figure 7: Average sulphate of supply **w**ells**.**

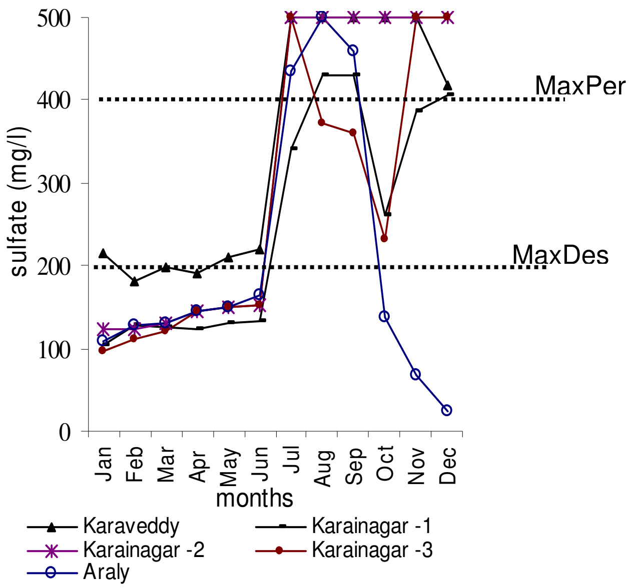

Figure 8: Sulphate values at supply wells.

Electrical Conductivity

The EC values of the tested water supply wells ranged from 450 µs/cm to 6500 µs/cm. Water supply well at Karaveddy and Araly (Figure 10) were above maximum permissible level during June to December and June to September respectively. In the case of Karainagar-1 and Vaddukoddai, EC value was in-between desirable and permissible level. However, they have shown values above permissible level during some months of the year. Other supply wells were found below permissible level for all months of the year. Based on average EC value, only supply well at Karaveddy (Figure 9) was above permissible level. The study by Maheswaran (2003) showed that in Kayts, Valvettithurai and Karaveddy areas, EC is very high. When the rainwater seeps through the soil, salts such as $CaCO_3$ and $CaSO_4$ dissolve in the seepage water and washed into the wells. These salt solutions could increase EC of groundwater. The wells at Karaveddy and Araly have a severe salinity problem when compared to other tested wells.

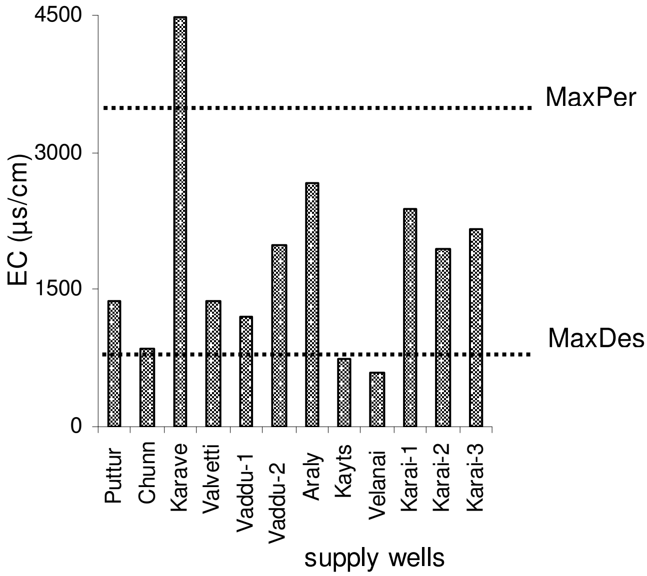

Figure 9: Average EC of supply wells.

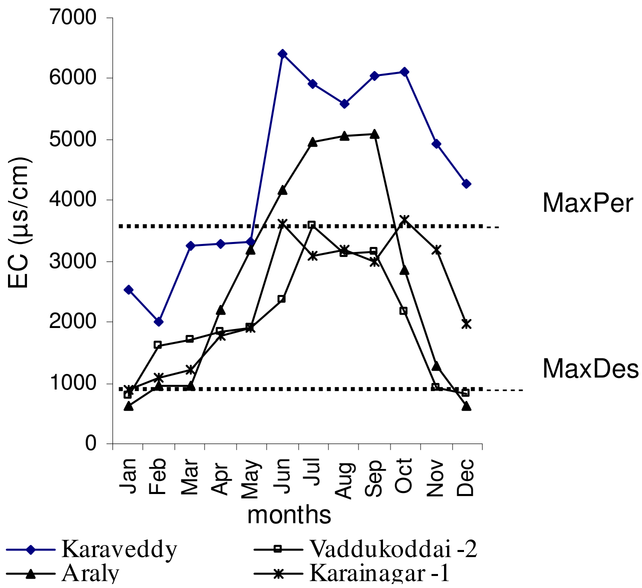

Figure 10: EC values of supply wells.

Nitrate as N

In all water supply wells, average value of nitrate nitrogen was below the maximum permissible level (10 mg/l) during this study period. Chunnakam well showed the highest concentration of nitrate (as N) ranging from 4.3 mg/l to 8.0 mg/l throughout the year as there is an intensive agricultural area in the surrounding. The sources of pollutions are inorganic fertilizers and chemicals associated with the fertilizer which come through the leachate. The high nitrate content in water is related to the occurrence of cancer. According to Gunasekaram (1980) research carried out in 1973-1977, the Northern Province had the highest incidence of cancer in Sri Lanka (Sivarajah, 2003). The incidence of esophageal cancer in the Northern Province was double the national level. This could be partly attributed to the high nitrate content in water and the consumption of vegetables with high amounts of insecticides in them (Sivarajah, 2003).

Nitrite as N

Fluctuation of nitrite as N was not in a systematic manner. Normally, nitrite will oxidized to nitrate in open dug wells. The concentration of nitrite (as N) was below maximum permissible level (0.01 mg/l) in all the months at Karaveddy water supply well. Other water supply wells were above permissible level during some months of the year. Based on the average value, water supply wells at Araly and Karainagar – 3 were above permissible level.

Total phosphate

All water supply wells had below maximum permissible level (2 mg/l) of total phosphate in all months of year. In this study, higher total phosphate contents (0.58 mg/l) were observed in Vaddukoddai water supply well.

Fluoride

Jaffna Peninsula water supply wells have fluoride in the range from undetectable to 0.63 mg/l during July to December. The concentration of fluoride was below maximum desirable level (0.6 mg/l) in all tested water supply wells. In most of the water supply wells in Jaffna Peninsula, regarding the concentration of fluoride, the value above the recommended level was not a problem but all supply wells show less than 0.6 mg/l which leads to deficiency of fluoride. While the use of fluorinated toothpaste is used extensively in Sri Lanka as a preventive measure against dental caries, most of the people in the rural area in Jaffna do not use fluorinated toothpaste.

Total iron

Jaffna Peninsula water supply wells have the total iron in the range from un-determine value to 0.78 mg/l. All water supply wells were below maximum permissible level (1 mg/l) during all months of the year. Putz (2004) said long time consumption of drinking water with a high concentration of iron can lead to liver diseases (hemosiderosis).

pH

The results indicate that the pH values of water supply wells ranges from 7.3-7.9 which was slightly alkali. There was no health-based guideline value is proposed for pH. Although pH usually has no direct impact on consumers, it is one of the most important operational water quality parameters (WHO, 2006).

Arsenic and manganese

The values of arsenic and manganese were at undetectable levels in all months of the year in all water supply wells.

Bacteriological characters

Total coliform and E-coli

The total coliform and E- coli were not found in all supply wells because the supply wells are continuously chlorinated to maintain minimum of 0.2 ppm residual chlorine at the end point.

Conclusions and suggestions

Conclusions

Water supply well at Velanai, Puttur, Chunnakam, Valvettithurai and Kayts sump did not have water quality problem and can be used continuously for human consumption. Water supply wells at Karainagar and Vaddukoddai were below permissible level of most physical, chemical and bacteriological properties except some of the chemical properties during few months. Hence, extraction of water from above water supply wells could be continued but continuous monitoring of chemical parameters is essential. Karaveddy and Araly wells are not suitable for drinking purpose because most of the chemical and physical characters of these wells exceed the Sri Lankan standard levels. The presence of less fluoride in all water supply wells is not known to the vast majority of the people in Jaffna district who are almost totally ignorant of the danger of deficiency of fluoride in their drinking water. There was no microbial problem by total coliform and E-coli due to continuous chlorination.

Suggestion

- A continuous monitoring program is essential to identify the situation of the quality of water to safeguard the public health.
- New drinking water sources should be identified for problematic areas such as Araly and Karaveddy. Karaveddy RO plant can be continued to use and balance water should be diverted far away from the source.
- Awareness should be created among the residents in the study area about less Fluoride content in water and associated dental problems.

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The effect of land use on quality of groundwater: A case study from Jaffna peninsula

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Abstract

The study was focused on quality of groundwater in different land use. Sixty eight wells were selected randomly from different land use such as high land crops, mixed crops, banana field and paddy field. Groundwater samples were collected from wells and an analysed periodically from July to December 2007 for nitrate-N, electrical conductivity (EC), total dissolve solid, pH and chloride. The nitrate-N content was determined colorimetrically using the brucine method. The pH and EC were measured by using pH meter and conductivity meter, respectively. Mohr's titration was used for determine of the concentration of chloride. Results revealed that there was a significant correlation between land use and nitrate-N concentration in groundwater. High nitrate-N concentration of groundwater was observed at highland crops land use followed by mixed crops and there was no significant difference between high land and mixed crops. However, there was no significant difference between highland and mixed crops. Similarly, there was no significant different between paddy and banana. Concentration of nitrate –N in paddy and banana land use was less than the recommended level of 10 mg/l. There was significant different between high land and mixed crops to banana and paddy land use. But, there were no correlation between land use and electrical conductivity, total dissolve solid, pH and chloride in groundwater.

Introduction

Groundwater is an extremely valuable resource particularly where it is the only source for water supply and pollution of groundwater resources is a matter of serious concern. Among the major threats to groundwater source, leachates from human and animal waste and chemical used in agriculture are very serious. Agricultural leachates often contribute significantly to groundwater pollution. Among the chemical species that pollute groundwater supplies, nitrate is not common. This originates from human and animal excreta as well as from nitrogenous fertilizers that are often used in large quantities in agriculture.

The high nitrate levels recorded in well waters of the Peninsula's agricultural areas is very likely related to the intensive cultivation practiced in that region (Mageswaran and Mahalingam, 1984, and Nagarajah *et al*., 1988). Farmers apply very large amount of animal wastes, green manures and crop residues in addition to heavy application of inorganic fertilizers. In addition, irrigation is practised at a higher rate and often water is applied to crops through flood irrigation. In view of the fact the limestone aquifers are covered by thin mantle of highly permeable calcic latosols, rapid movement of any nitrate which is not utilized by crops can reach the aquifers resulting in high nitrate levels (Nagarajah *et al*., 1988).

The farmers cultivate the crops in different ways in Jaffna peninsula. The crops are cultivated as high land crops or highland with banana or banana alone. Paddy is cultivated during Maha season in separate land. Depending upon the cultivable lands the amount of fertilizer, fertilizer application interval, amount of irrigation, irrigation interval differs. The objective of this study is to asses the ground water quality under highland, banana and mixed crops.

Materials and methods

Selection of the well

Sixty eight wells were selected randomly In the intensive agricultural areas from different cropping patterns high land crops (chilli, onion, brinjal, tobacco), mixed crops (high land crops with banana), banana field and paddy field. Since the well in the paddy field is not much existing in the Peninsula, the number of well selected for sampling was seven. At the same time, forty one wells were selected for analysis under high land crops because large extent of land is under high land crops. Thirteen and seven wells were selected from mixed crop and banana, respectively. All the selected wells were used not only for irrigation but also for drinking purpose.

Collection of water samples

Samples were drawn from the surface area of the wells using water sampler for a period of six consecutive months beginning from July to December in 2007, at monthly interval. Samples bottles were prepared to collect the water samples to meet prerequisites of chemical analysis. Each sample was poured into sample bottles after rinsing it twice or thrice with the same water and covered with lid. Samples were then taken to the laboratory for chemical analysis.

Chemical analysis of water samples

The nitrate-N content was determined colorimetrically using the Brucine method (Taras, 1958).The pH and EC of the water samples were measured by using pH meter and conductivity meter, respectively. Mohr's titration (0.01 AgNo3) was used for determination of the chloride content.

Rainfall data was obtained from meteorological department, Jaffna during the study period as secondary data to analyse the correlation between rainfall and quality of water. Measured all chemical parameters were compared with the Sri Lankan drinking water standard and recommended irrigation water quality standards. All the measured data were analysed statistically for the significant different between land use classes and measured parameters.

Results and discussion

pH

pH levels in the sixty eight wells water were varied during the period of study. The values ranged from 6.9 to 8.1 and all the wells were suitable for drinking purpose. Figure 1 shows the average pH value of all selected wells. There were no correlation between land use and pH. The result of the study was supported by Puvaneshwaran (1986) and Nagarajah *et al*. (1988). According to Ayers and Westcot (1985) normal pH range for irrigation water is from 6.5 to 8.4. All the tested wells were within the range irrigation water and there were no influence of land use on pH.

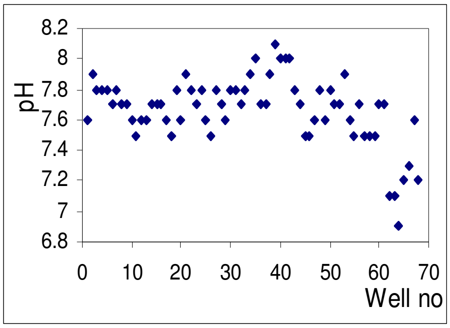

Figure 1: Average pH in groundwater.

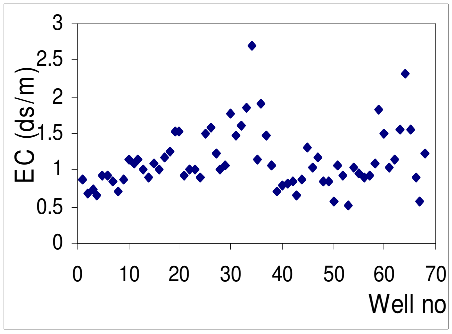

Figure 2: Average EC in groundwater.

Electrical conductivity (EC)

A high value of EC generally means high degree of salinity. Therefore, EC is considered as an important water quality parameter in assessing drinking water as well as irrigation water. The EC is widely used to classify the water as low, medium and high saline water. The EC levels varied during the study and ranged from 0.43 ds/m to 2.99 ds/m. Figure 2 shows the average EC value of all sampled wells. Since measured values were less than permissible level of 3.5 ds/m, all the wells are suitable for drinking. Nine percentages of the wells had EC values below 0.7 ds/m and 91% of the wells had the EC values between 0.7 – 3 ds/m. Hence, most of the wells are slight to moderate for irrigation purpose. Panabokke *et al*. (2002) reported that significant rise in EC values of water following the Maha rains in November, due to the fact that a large part of the leaching or washing out of the solutes in the soil. In some of the wells EC values were increased during November due to leaching of the salt from soil. There were no correlation between land use and EC of groundwater.

Chloride

Sources of chloride in groundwater include seawater, fertilizers, sewage water industrial pollutants, and saline residues from soil and minerals such as biotite. Figure 3 shows the average concentration of chloride of all measured wells. The chloride concentration was ranging from 28 to734 mg/l. All the wells were suited for drinking. Of the sixty eight wells measured, results showed that 73.53% of well water was chloride content of less than 200 mg/l and 26.47% were with in the range of 200 mg/l to 1200 mg/l. According to the classification of Bauder *et al*. (2003) 12% of the wells had the chloride value below 70ppm (safe for all plants) and 33.82% of the wells had chloride values between 70 -140 ppm (sensitive plants show injury), 47.06% of the wells had the chloride values between 141-350 ppm (moderately tolerant plants show injury) and 7.35% of the wells had chloride values above 350 ppm which causes severe problems

De Silva and Ayomi (2004) stated that chloride concentration in excess of about 250 mg/l can give rise to detectable taste in water. There were no correlation between land use and chloride in groundwater even in high land and mixed crop high withdrawal rate. Concentration of chloride in Paddy land was very high because, during the rainy season the runoff water enters into the well with salt.

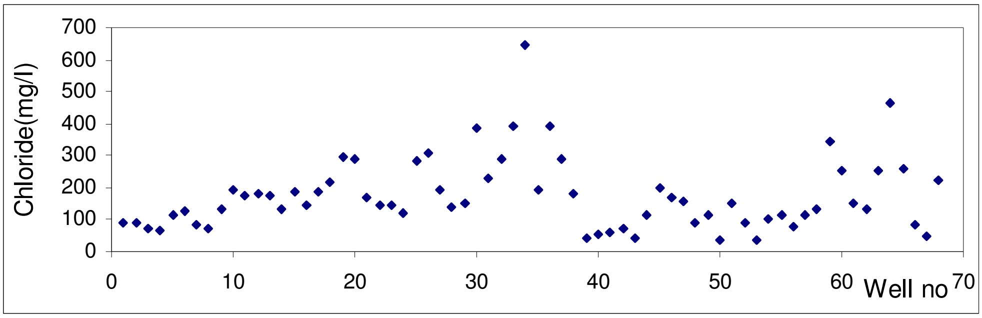

Figure 3: Average chloride in groundwater.

Nitrate-N

The nitrate- N varied in all the months in sixty eight well and values were ranged from 0.16 mg/l to 17.41 mg/l. The highest value of nitrate-N was observed as 17.41 mg/l at Kondavil. Out of sixty eight wells, 81% of the wells founding intensified agricultural areas was not recommended for drinking but were accepted for irrigation requirement. The farmers have the practice of applying excess amount of inorganic fertilizers. The excess fertilizers leached out to the shallow groundwater. Dissanayake and Weerasooriya (1985) pointed out in hydro geochemical atlas of Sri Lanka that Jaffna Peninsula has the highest nitrate content among the groundwater of Sri Lanka due to higher usage of fertilizers. Gunasekeram

(1983) studied extensively on groundwater contamination in the Jaffna Peninsula and found that the nitrate levels exceeded the WHO limits due to mixing up of abundant nitrogenous waste matter and synthetic and animal fertilizers with shallow groundwater.

The above mentioned problem occurs not only in Jaffna Peninsula but also some other parts of the Sri Lanka. Vaheesar (2001) showed that the highest nitrate content was observed at Mamunai, Batticaloa district as 96.60 mg/dm^3. Kurupuarachchi and Fernando, 1999 stated that increase in nitrate concentration is approximately 1 – 2 mg/l per year.

Presence of nitrate-N in different land use

Figure 4 shows nitrate-N in the groundwater in the different land use classes such as high land crops, mixed crops, banana and paddy. High nitrate-N concentration of groundwater was observed at high land crop land use and followed by mixed crops. Most of the wells were exceeded the recommended level for drink water standard. Concentration of nitrate –N in paddy and banana land use had less than the recommended level of 10 mg/l.

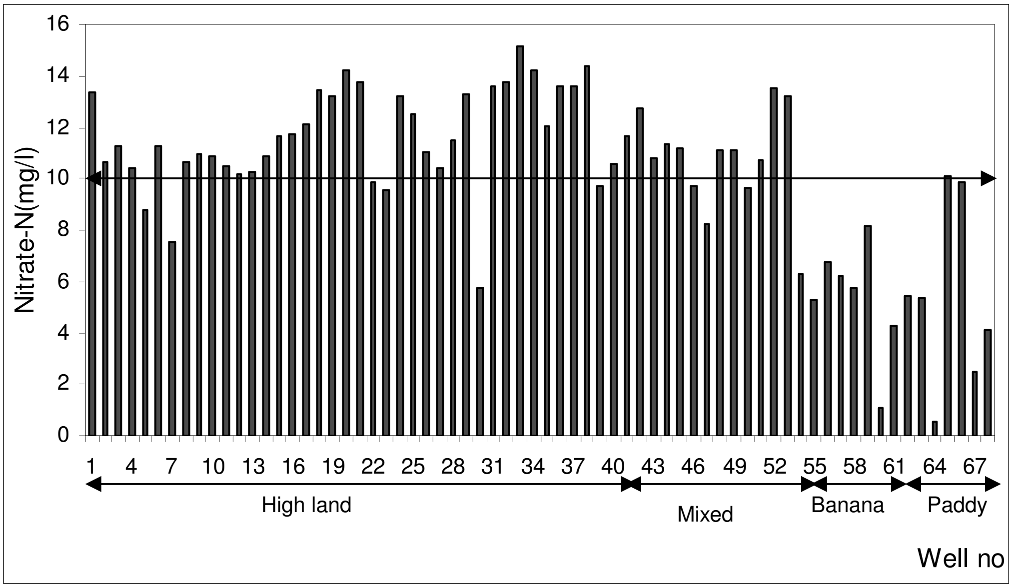

Figure 4: Average nitrate-N in the groundwater in the different land use classes.

In intensified agricultural areas, farmers used to practice year round cultivation without fellow period. In addition to that they are practicing high intensity cropping (planting three crops at a time in the same field; for example amaranthus (15-20 days), radish (45 days) and Onion (90 days)) to keep the land for maximum utilization. Hence they are using high fertilizers to satisfy all the stages of the crop.

Table 2 shows the statistical analysis of significance among different land use. Mean nitrate-N concentration in groundwater of high land and mixed crops significantly ($p < 0.05$) differed from banana and paddy fields. This may be due to the effect of the rate of application of fertilizer and soil type. There was no significant different between high land crops and mixed crops and also mean nitrate concentration of paddy field not significantly differed from banana crops.

Table 2: Statistical analysis of groundwater nitrate-N in different land use.

Land use	**Mean nitrate-N**
High land crops	11.6303[a]
Mixed crops	10.7369[a]
Banana	5.4148[b]
Paddy	5.3593[b]

(Means with same letter aren't significantly different in Duncan's grouping).

The result of this study also was supported by the study of Kuruppuarachchi *et al*., 1990. In Jaffna Peninsula the condition of paddy soil (due to hardpan formation) restricts the leaching of nitrogen fertilizers to groundwater. Cultivation of banana is normally under basin irrigation with organic fertilizers. Before planting of banana suckers farmers burry green manures into the pits. They keep the plants in the field nearly for five years. Most of the farmers are not using any inorganic fertilizers for cultivation. Premanandarajah *et al*., 2003 reported that the addition of organic manure increases nitrogen retentions capacity and reduces nitrate loss by leaching in sandy soils, therefore crops can efficiently utilize the applied fertilizer and residual N will remain in the soil for next crop. Since nitrogen retention increases with organic fertilizers, this may be the reason for low nitrate-N concentration in groundwater in banana land use. Hence one of the ways to reduce nitrate pollution of groundwater is by incorporating organic manures.

The highest concentration of nitrate nitrogen occurred during the October and then reduced during November because of high recharge to the well which dilutes the concentration of nitrate in high land and mixed crop. Again the concentration was increased during December due to the continuous leaching of nitrate –N from the soil. In most of the well in paddy and banana the concentration was high during October and then gradually decreasing because of dilution.

Lawrence *et al*., 1988 reported that the limestone aquifer of the Peninsula is not only highly vulnerable to pollution but also subject to land use activities likely to generate pollutants.

Conclusion and suggestions

All the wells are acceptable for irrigation based on pH and nitrate. On the basis of chloride and EC the wells could be classified as slightly moderate. All the wells are acceptable for drinking based on pH, EC and chloride. But 81% of the wells are not suitable for drinking due to high nitrate -N concentrations. There was a good correlation between land use and nitrate-N concentration in groundwater. High nitrate-N concentration of groundwater was observed at high land crops land use and followed by mixed crops. There was no significant difference between high land and mixed crops. There was significant different between high land and mixed crops to banana and paddy. But, no significant different between paddy and banana cultivation was observed. It is note worthy that the level of nitrate concentrations of water show significant influence by land use.

Suggestions

- Construction of proper lining of the agro well to prevent the run off water into the well.
- Promote the use of bio fertilizers instead of using chemical fertilizers in agriculture.
- Introducing the micro irrigation system to reduce the extraction of aquifer and also to reduce the leaching of ions from the soil profile to ground water aquifer by applying accurate required amount of irrigation water.
- Awareness program to public through the extension officers regarding the dangerous situation of quality of finite natural resource.

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Operational challenges of surface water and groundwater treatments

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Abstract

Groundwater resources in Batticaloa and Trincomalee are often limited although rivers in the region are perennial with water of low turbidity. Water treatment plants based around a membrane filters provided a reliable means of providing the quantities of water needed for IDP camps. Raw water measurements showed turbidity of between 25 and 100 NTUs and faecal coliform levels of between 50 and150, though none were found after treatment. Output of one plant with 10 filters however was reduced by 30% within 2 months caused by Manganese and Iron Oxides that were not displaced by backwashing. Filters were "rejuvenated" with a solution of chlorine and citric acid that boosted capacity by 80%. The maximum head pressure of 4 metres was exceeded periodically and may have contributed to the permanent reduction in performance of some of the filters.

Iron concentrations of between 0.5 mg/l and 3 mg/l were found in the raw water that did not pose a threat to health, or have an intolerable taste, but on addition of chlorine turned an objectionable reddish brown colour. Polyphosphates were added to the water to "sequestrate" the iron before the addition of chlorine. Trials were carried out to find out appropriate concentrations of sodium tripolyphosphate when used with High-Test Hypochlorite (HTH) for water treatment. Changes of PH and conductivity were also measured. HTH solutions of 4.2 mg/l were tested at the upper limit of concentrations that were known to cause the objectionable colour. No colour change was observed with 100 mg/l but doses of 50 mg/l and below did not prevent the colour formation after HTH was added. Groundwater from some areas has iron content greater than that permitted under WHO standards.

This study also evaluated the performance of 9 low-cost sand filters in the Kalawanchikudy area of Batticaloa to remove turbidity and reduce iron with concentrations of up to 7.5 mg/l from groundwater. The filter design consisted of two parts combined in a single unit, minimising the cost of materials and maintenance. The top of the filter contained gravel and charcoal for the adsorption of organic matter, suspended materials and the majority of the iron in the raw water, while the bottom part consisted of river sand and gravel to reduce further the remaining iron. Cost of filter materials was less than 6000 LKR[1]. Average efficiency of iron removal was 93%. Raw water with iron concentration of 7.4 mg/l and an average turbidity of 14 NTU was reduced to 0.5 mg/l and 1 NTU respectively.

[1] Sri Lankan Rupees

Treatment of water using micro filtration

Introduction

What does it do? The filter module used[2] was a quickly installed and low maintenance water filtration system, which is ideally suited to providing drinking water for small or large communities, and is particularly useful for disaster relief applications.

Where it can be used? It is designed to treat raw water of up to 500 NTU of turbidity but not to treat feed waters that are brackish, saline or salt affected, or remove dissolved minerals such as arsenic or fluoride.

How does the filter work? The technology is based on a self-contained membrane filtration system that operates under minimal head, and without the need for conditioning chemicals. The design is compact, robust and self-cleaning and can be deployed with a medium level of technical competence. When operational, the unit is housed within a protective tubular canister. Untreated feed water permeates the outer walls of thousand of fibres where the filtration process occurs. Bacteria, Protozoa, Viruses & other contaminates greater than 0.1 microns are removed and clean water is produced. The filter can be re-cleaned periodically using a manual cleaning procedure.

Skyhydrant High Volume Filter Plant

Several Skyhydrant modules can be arranged in parallel to form an array. A filter plant with 10 units can purify 70 cubic metres of raw water a day or enough for 30,000 people (using SPHERE minimum standards). Oxfam constructed 5 plants of similar size in Trincomalee and Batticloa districts. Operational characteristics are shown in Table 1. All the filtrates of the Oxfam filter plants were found to be free of coliforms. However the supply was chlorinated as a precaution to ensure clean water through the collection process, to bowser, to holding tank, to collection bucket, and finally home.

Filter performance

The output of most of the 10-unit Skyhydrant plants decreased by 30% after 2 months of operation and Manganese & Iron oxide deposits were noticed blocking the fibre pores. Back washing was not sufficient to remove the oxides but cleaning with 1000 ppm chlorine (Sanclean), and 500 ppm Citric Acid (Acidclean) enabled the filtration rate to recover by 80%.

[2] Skyhydrant filter module manufactured by the Skyjuice Foundation.

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The diagram opposite shows some of more than 10000 individual micro fibres, each slightly larger than a cotton thread, which go to make up a Skyhydrant module. The fibres, which span the entire length of the 1.2 meter long filter module, are permanently mounted at each end using a specially formulated sealing compound.

Each fibre is like a tiny hollow straw through which pure clean water passes after being filtered of impurities while permeating the outer membrane of the fibre. The filtered water trickles from the hollow tube ends.

The fibres are made of Polyvinylidene Fluoride (PVdF) material; PVdF is a pure, inert, thermoplastic fluoropolymer. It is also known as KYNAR or HYLA.

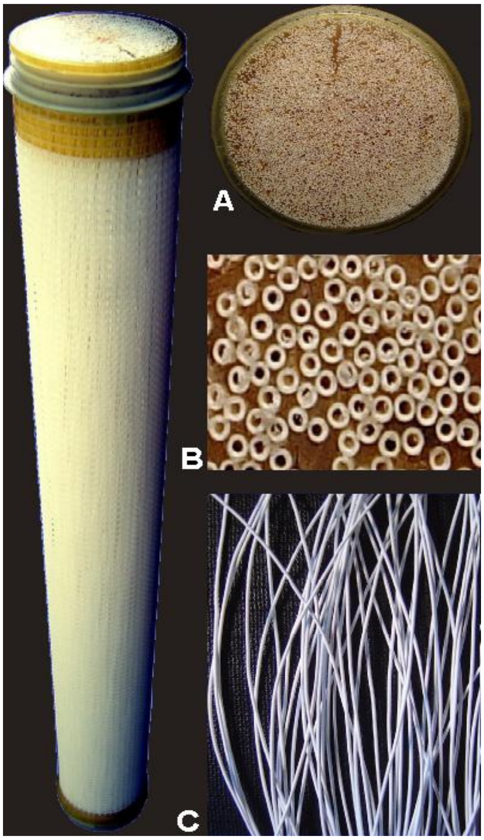

Table 1: Standard operational characteristics of the 10-unit Skyhydrant plant.

No	Characteristics	Units
1	Raw water turbidity range	25 ~ 100 NTU
2	Raw water coliform count	50~ 150 colonies
3	Filtered water turbidity	Less than 5 NTU
4	Filtered water coliform count	0
5	Average clean water production/day	70 m^3
6	Fuel (Kerosene)/day – little petrol needed to start the fuel pumps	4 litre
7	Necessary HTH for disinfection /day	500g
8	Back washing frequency	Each 10,000l

Pressure damage to filter fibres

It was observed that the output of some filter units did not recover after cleaning and that membrane fibres were damaged. The pressure difference between the raw water and filtered water storage plays an important role in the operation of the Skyhydrant filters. The water level between the two tanks varies continuously although there should be a maximum of 4000 mm and a minimum of 500 mm (see Figure 1). It was found that in one plant this pressure head had increased to 5500 mm periodically, and had damaged some of the fibres permanently.

Comparison of different treatment technologies

Operational effectiveness compares well with other treatment technologies (Table 2).

Skyhydrant filters cost US$ 3500 each so a plant with 10 units would be more than US$ 40,000. However the filters, if treated well, can last 10-20 years and the advantages of flexibility, ease of installation and maintenance are considerable. In addition since microfiltration is a new technology, unit costs are likely to decrease in the future.

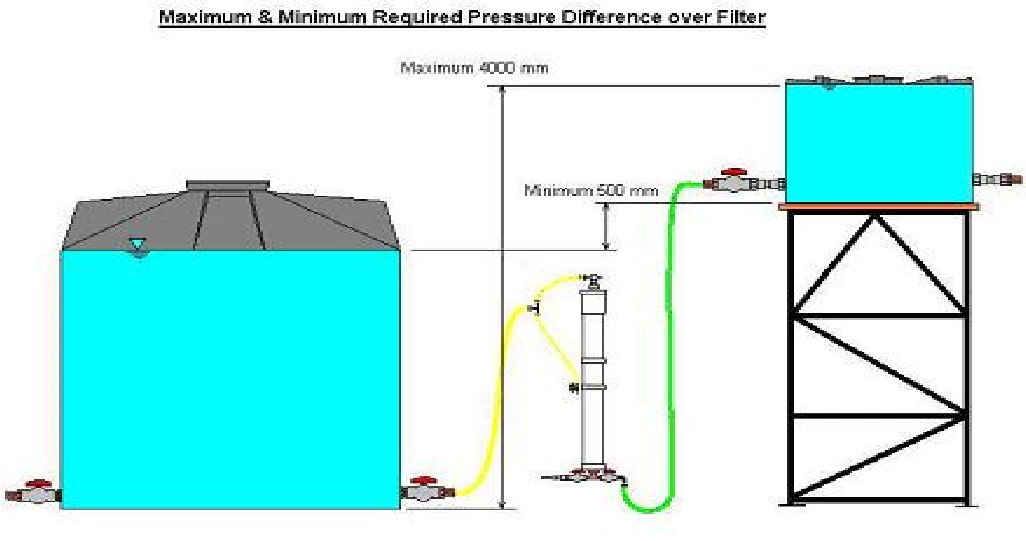

Figure 1: Skyhydrant Filter Plant Unit.

Conclusion

Based on the experience gained the 5 Skyhydrant High Volume filter plants, have shown good performance and have been especially effective in an emergency context. Compared with other available water filtration systems, the simplicity of maintenance and ease of installation make it a good option for emergency water supply.

Table 2: Comparison of treatment technologies using a raw water source of 100 NTUs.

Characteristics	**Skyhydrant filter**	**Slow sand filter**	**Rapid sand filter**
Pre screening	No (Except large particles)	Yes	Yes
Aeration	No	Yes	Yes
Flocculation	No	Yes	Yes
Operational complexity	Low	Low	High
Installation time frame	Short	Long	Long
Implementation	Medium technical skill	High technical skill	Complex Technical skill
Out put	No bacteria (chlorination ensures safe delivery to users).	Low level of bacteria (Chlorination essential)	Moderate level of bacteria (Chlorination essential)
Maintenance	Low	Comparably high	Comparably high
Knowledge requirement	Basic or unskilled	Semiskilled	Skilled
Space requirement	Compact	Comparably large	Relatively less
Suitability	Suited for emergency response	Suited for medium scale longer term solutions	Suited for large scale longer term solutions

Treatment of iron colouration in drinking water using polyphosphates

Introduction

Iron is one of the most abundant metals in the Earth's crust. It is found in natural fresh waters at levels ranging from 0.5 to 50 mg/litre. Iron is an essential element in human nutrition and there is limited health hazard associated with iron intake. However taste and appearance of drinking water are affected by high iron content (WHO, 1984).

In the first edition of the Guidelines for Drinking-water Quality, published in 1984 (WHO, 1984), a guideline value of 0.3 mg/litre was established, as a compromise between iron's use in water treatment and aesthetic considerations. No health-based value for iron was proposed in the 1993 Guidelines, but a value of 2 mg/litre was given as a precaution against storage in the body of excessive iron.

Anaerobic groundwater may contain ferrous iron at concentrations of up to several milligrams per litre without discoloration or turbidity in the water when directly pumped from a well. On exposure to the atmosphere, however, the ferrous iron oxidizes to ferric iron, giving an objectionable reddish-brown colour to the water. There is usually no noticeable taste at iron concentrations below 0.3 mg/litre, although turbidity and colour may develop (WHO, 2004).

In Batticaloa district, iron concentration in groundwater generally varies between 0.5 mg/l and 7.5 mg/l (total iron) (Jude Nimalan, 2007). This does not pose any great threat to health. However a yellowish colour frequently appears after chlorinating the water. This poses an aesthetic problem, confirmed by user complaints. Trials were done to remove iron by oxidization, precipitation, and sedimentation, but without success. The reason was assumed to be the low concentration of iron, not resulting in sufficient precipitation to facilitate the settlement of ferric iron particles.

Stabilisation or "sequestration" of iron with polyphosphate

According to NDWC (National Drinking Water Clearinghouse, 1998), an alternative method to prevent aesthetic problems related to iron is "sequestration". Sequestration is the addition of chemicals to groundwater aimed at controlling problems caused by iron and manganese without removing them. These chemicals are added to groundwater at the wellhead or at the pump intake before the water has a chance to come in contact with air or chlorine. This ensures that the iron and manganese stays in a soluble form. If the water contains less than 1.0 mg/l iron and less than 0.3 mg/l manganese, the addition of polyphosphates followed by chlorination can be an effective and inexpensive method removing colour. No sludge is generated in this method. Below these concentrations, the polyphosphates combine with the iron and manganese preventing them from being oxidized. Any of the three polyphosphates (pyrophosphate, tripolyphosphate, or metaphosphate) can be used.

Trial methodology

The Chlorine demand test or "jar test" was used to determine the chlorine requirement for the hand dug well used to supply drinking water to the IDP camp of Savakuly, Batticaloa District. A 1% solution as HTH was prepared by mixing 10 grams of HTH (average Cl2 content of 70%) with 1 litre of water filtered through a Nishimen® ceramic filter followed by activated carbon, silica sand, zeolite and mineral sand.

Five white buckets (Oxfam buckets) were filled with 10 litres each of the water to test. Different doses were injected (2.1 mg/l, 4.2 mg/l, 6.3 mg/l and 14 mg/l) using a 5ml syringe. The first bucket was kept without chlorine to be used as a control for eventual colour change. The high dose of 14 mg/l was tested for the sole purpose of colour change observation. After a 30min contact time (from the last injection), free chlorine residual was measured using a Lovibond comparator for chlorine range 0 – 4 mg/l (comparator disc No 14 60 20).

Sodium tripolyphosphate dose determination

Following the free chlorine residual readings, a HTH dose was chosen to conduct the sodium tripolyphosphate test. Parameters used to select the HTH dose are: a) minimum free chlorine residual of 0.2 mg/l; and b) HTH dose with noticeable change of colour.

Again, the common "jar test" method was used to determine the sodium tripolyphosphaste dose requirement to prevent the colouration of Savakuly hand dug well. A 1% solution as sodium tripolyphosphate was prepared by mixing 10 grams of sodium tripolyphosphate with 1 litre of filtered water, according to the same procedure as for the HTH solution previously.

White buckets were filled with 10 litres of water. To the first bucket there were no chemicals added. The selected HTH dose (with no sodium tripolyphosphate) was added to the second bucket. These buckets were kept through the test series in order to make colour comparison. The remaining buckets were tested with varying amounts of polyphosphate until a dose that prevents colour formation was found.

Sodium tripolyphosphate test and colour observation

Following the chlorine demand test and colour change observation, we performed a sodium tripolyphosphate demand test. The adequate dose of sodium tripolyphosphate would be determined by visual observation of samples and the eventual non-coloration of sample water. All samples, except one blank for visual comparison, received different doses of sodium tripolyphosphate, immediately followed with 4.2 mg/l of HTH. Each sample had a minimum contact time of 15 minutes to observe any colour change.

No colour change can be observed with a dose of 100 mg/l of sodium tripolyphosphate. A dose of 50 mg/l of sodium tripolyphosphate did not prevent colour formation after addition of chlorine. Laboratory analysis of each sample was conducted on the following day, including total iron, apparent colour, conductivity and pH. Those tests were not performed on the same day due to security and administrative constraints.

Table 3 presents some laboratory analysis results. It is difficult to make any conclusive observations from those results. We can note that pH seems to be slightly affected by the addition of sodium tripolyphosphate, but this change looks negligible. Turbidity results are the same for the blank sample (1A) and the sample without colour formation (5C), which would indicate a lack of precipitation from ferrous iron into ferric iron. Other turbidity results could be affected by the delay between sampling and analysis; precipitates may have settled to some extent and hence may not have been present in the collected samples.

Figure 2 compares different apparent colour analysis results for sodium tripolyphosphate demand test's samples. We can observe that apparent colour decreases with samples that have a higher dose of sodium tripolyphosphate. We can observe that sample 5C still has a higher apparent colour than the raw water sample (56 units versus 42 units), however this difference was not noticeable to the naked eye.

Table 3: Laboratory analysis on chlorine demand test.

Sample No	HTH dose (mg/l)	Total iron (mg/l)	pH	Conductivity (mS/cm)	Turbidity (FAU)
1A	0	0.30	7.5	0.1	3
2A	3	0.30	7.5	0.1	3
3A	6	0.27	7.5	0.1	4
4A	9		7.5	0.1	3
5A	20		7.7	0.1	2

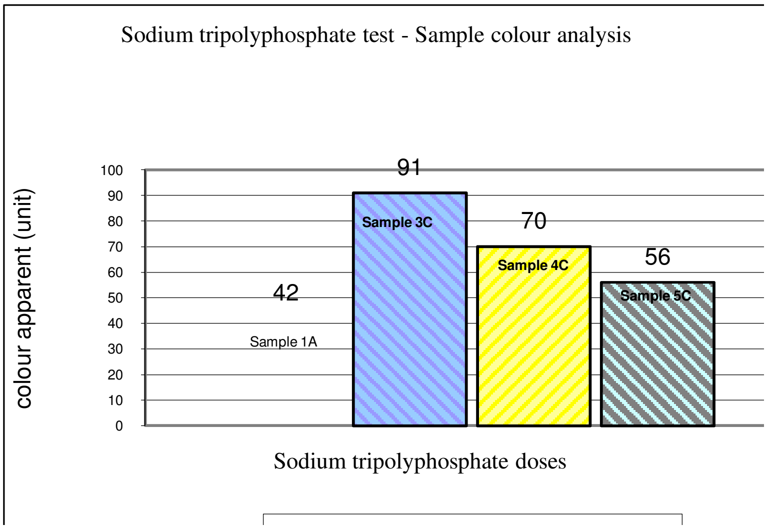

Figure 2: Sodium Tripolyphosphate – sample colour analysis.

Discussion and conclusion

This study was performed under security constraints as well as limited time and often improvised equipment. However, every effort was put to maintain a similar methodology throughout the field trial and sample analysis.

Oxfam GB works with several partners in Sri Lanka and especially Batticaloa district. It is thanks to the work of those partners with beneficiaries that the water colouration issue was communicated upwards to Oxfam GB team and its water quality specialist, in order to investigate potential solutions. This process itself is already a success as it shows a good communication and coordination between Oxfam GB and partner organisations.

This trial shows that the HTH dose threshold for water coloration is between 2.1 mg/l and 4.2 mg/l. Chlorination of the water, at this site, is performed using a batch process in the 4m^3 bowser, which travels between the well and the site (about 1 km).

Table 4: HTH requirement for chlorination.

HTH dose	**Bowser volume**	**Quantity of HTH required**
2.1 mg/l	4 m^3	12 grams
4.2 mg/l	4 m^3	24 grams

Table 4 shows the HTH requirements for doses of 2.1 mg/l and 4.2 mg/l in a volume of 4m^3. Even if one quantity is double the other one, both are still very small amounts of HTH, and control and precision are difficult. Most operators do not have knowledge of chemistry or chemical dosing, nor do they have instruments to weigh a quantity of HTH as this is often done through volumetric correspondence, using a plastic cup. Ensuring adequate control in order to determine and maintain a dose below the colouration threshold is impossible in an emergency situation, and even difficult during a stable period. And the operator would need chemistry training and adequate instruments to precisely measure chlorine doses.

Results of this study indicate that sodium tripolyphosphate (and any polyphosphate) can prevent water colouration due to the oxidation of ferrous to ferric iron. More trials are necessary to refine the determination of the optimum sodium tripolyphosphate dose. Unfortunately the context did not allow that at the time. Future study can be based on this preliminary trial, replicating the methodology in order to have comparable results, assuming the raw water quality is similar.

Recommendation for additional study

- Replicate experiment with more contaminated water (higher chlorine dose) to determine if the dose of NaPO depends on the quantity of chlorine or the quantity of ferrous iron. A review of the chemical reaction may answer that question.
- Full scale trial with water distribution in camp in order to look at the operational feasibility.
- Cost analysis of additional usage of polyphosphate.

Treatment of elevated levels of iron in groundwater using slow sand filtration

Introduction

Dissolved ferrous iron in groundwater is precipitated as ferric oxide when water is pumped. The water therefore often has an unacceptable taste and can stain laundry. Iron removal involves aeration of the water and filtration of the resulting ferric oxide.

Slow sand filters are one of the most convenient low cost water treatment methods for rural areas in developing countries, because they are simple and inexpensive to construct, operate and maintain. This study evaluated the performance of 9 slow sand filters (5 tube wells and 4 hand dug wells) to reduce the iron concentration and turbidity from groundwater sources in the Kalawanchikudy area of Batticaloa. Each filter is shared by 5 families and provides drinking water only, producing up to 350 litres per day.

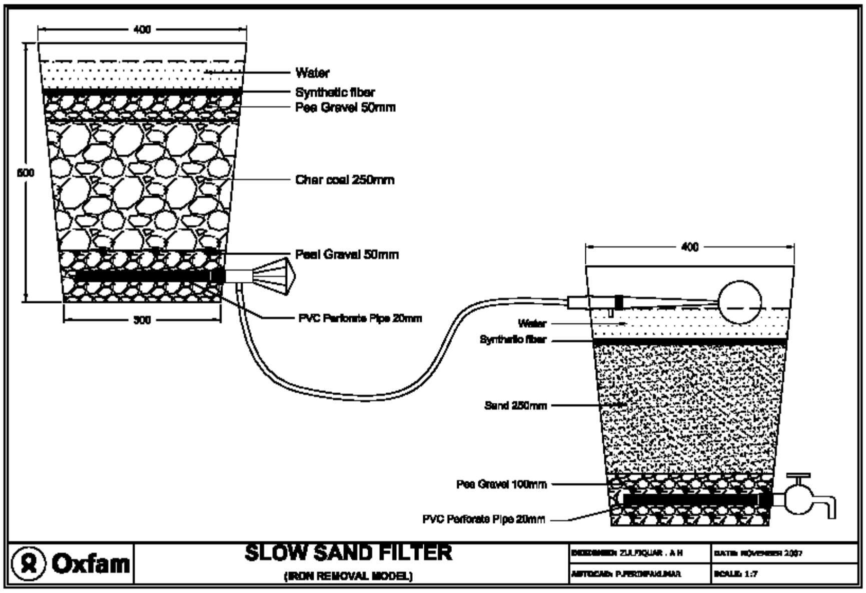

Figure 3: Detail of the sand filter.

Materials

The filter unit consists of two parts, the top filter contains gravel and charcoal for the adsorption of organic matter, suspended materials and the majority of the ferric iron in the raw water, while the bottom part consists of river sand and gravel to reduce further the remaining ferric iron by passing through a sand bed (see Figure 3). In addition, synthetic fibre was placed on the surface of both parts of the filters to retain floating suspended particles. The cost of materials for each filter was less than 6000 LKR.

Operation

Water passes slowly through the filter at a rate of 0.1-0.2 m/h. During this passage the water quality is improved by removal of total iron. However due to the gradual increase of suspended or inorganic matter, the filter unit efficiency decreases after some time. Washing the filter media using clean water restored the filtration capacity.

Analysis

The study was conducted with water from shallow wells over 6 months. Iron and coliforms were the main parameters to judge the performance of the filter, although turbidity and flow rate were noted. Filter efficiency was established by chemical analysis.

Iron concentration was assessed by colorimeter using the FerroVer Iron method.

Bacteriological tests were conducted with a DelAgua kit using an incubator.

PH was gauged with a pool tester. Tablets were dissolved in the sample and the resulting color compared using a colorimetric method. The pH was 7.5.

Conductivity was measured using portable electronic stick meters. The conductivity range was between 500 and 600 µs/cm and there was no significant conductivity difference between the inflow and the outflow.

Results

Average iron removal was found to be 93%. Raw water with iron concentration of 7.4 mg/l and an average turbidity of 14 NTU was reduced to 0.5 mg/l and 1 NTU respectively. Influent and effluent concentrations of Iron are shown in Table 5/Figure 4. Only two bacteriological tests were completed and both showed zero faecal coliforms.

Maintenance is shared between the 5 families and training was given to all users. Monitoring visits of the tube wells indicate that the majority is cleaning the synthetic fibre every three weeks and washing other contents of the lower and upper units once every 4 months as instructed. The others are waiting slightly longer until the level of contamination and turbidity impedes the flow rate. There is no maintenance cost.

Table 5: Iron filtration rate.

Total iron (mg/l)	2007			2008					
	13 Nov	22 Nov	10 Dec	06 Feb	15 Mar	20 Mar	28 Mar	10 Apr	20 Apr
Inflow	7.40	7.20	7.00	7.10	7.30	7.40	7.40	7.20	7.40
Outflow	0.51	0.42	0.28	0.25	0.10	0.10	0.12	0.82	0.97

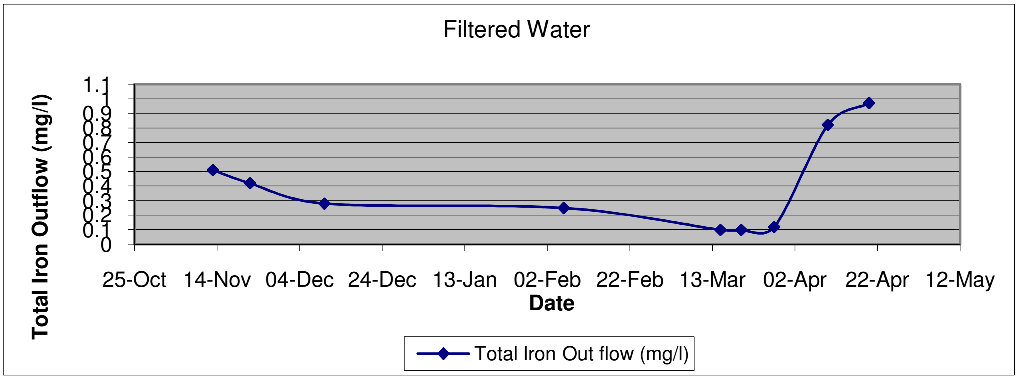

Figure 4: Iron filtration rate.

Discussion and conclusion

There is a floating valve used to maintain the appropriate water level in the second (lower part) filter unit to start the process of a biological filter skin on the surface of sand bed. This contains a wide variety of biological active micro-organisms that break down the organic matter, including bacteria and viruses. However, in normal operation the user is required to fill the sand filter before taking treated water. Unfortunately often this does not happen leaving the biological filter skin without water and at risk of drying out. In future, we plan to install a vertical elevated tap system instead of a floating valve to maintain the appropriate water level. In addition the white synthetic fibre will continue to be used to signal to the users when to clean the filter.

The sand filters have been promoted through community discussion and installed in various public places around the village. Other communities are showing an interest in the design. The increased community interest show this is type of technology is needed and community participation is very important to improve the unit further.

The sand filter was cheap to construct and easy to maintain although some modifications are needed to ensure the viability of the biological layer.

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Performance evaluation of coconut coir-pith in free water surface constructed wetlands

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Abstract

A study on wastewater treatment with a submergent wetland system was conducted at the University of Peradeniya, Sri Lanka. The primary objective of this study was to identify the improved potential for wastewater purification due to surplus organic carbon on microbiological activities and adsorption by coconut (Cocos nucifera) coir-pith as an alternative substrate material. Three constructed wetland units (Lysimeters-L1, L2 and L3) were used in the study, each having the dimensions of 5 m, 1 m and 0.6 m in length, width and depth, respectively. The substrate layer of each Lysimeter was amended with coconut coir pith and river sand as 100% river sand (L1), 100% coir-pith (L3) and mixture of then in equal compositions (L2,v/v=1:1). Hydrilla verticillata was planted in each Lysimeter with equal plant density. Influent and effluent water samples were analyzed for pH, conductivity, total suspended solids (TSS), total dissolved solids (TDS), five-day biochemical oxygen demand (BOD_5), total nitrogen (TN), ammonia nitrogen (NH4-N), and nitrate nitrogen (NO_3-N), phosphate phosphorous (PO_4-P) and faecal coliform bacteria in weekly interval. A parallel study was conducted at the laboratory in order to examine the best ratio of sand: coir-pith for the growth of H. verticillata. The removal efficiency of NH_4-N, PO_4-P, BOD_5, Total coliform and TSS in L2, were 93%, 74%, 54%, 93% and 62%, respectively, which were higher than the other two Lysimeters (L1 and L3). The results of effluent water quality analysis illustrated that the coir- pith is efficient in removing nutrients from wastewater over sand. The laboratory experiment revealed that the coir and river sand mixture in equal compositions provides the best substrate media for plant growth.

Introduction

Wastewater has to be treated well before discharge to the environment as it may contain various types of pollutants such as organic matter, heavy metals, toxic compounds etc. Inadequate treatment of wastewater may cause problems such as water pollution, the risk of human waste-related disease transmission, consequent damage to the environment etc., (Tanaka *et al*., 2006). Therefore, water reclamation is becoming a promising technique than pumping water from long distance, wasting higher cost and energy.

Constructed wetlands (CWs) have been used all over the world since 1950s to treat different kinds of wastewater such as food processing, runoff, landfill leachate, industrial, agricultural farm and mine drainage (Vymazal, 2005). Gravel, crushed rocks, cobbles, coconut coir-pith and calcite are the substrate materials that have been used in CWs (Akratos and Tsihrintzis, 2007; Namasivayam *et al*., 2001; Brix and Arias, 2005) to treat wastewater. However, all the materials that have been used in CWs reduce the adsorptive capacity with time due to saturation of particular substrate (Akratos and Tsihrintzis, 2007), reducing the performances of constructed wetlands with time. Tanaka *et al*. (2008) have shown that the use of coconut coir-pith in CWs lead to enhance denitrification. As well as, it has clearly shown that wetlands with plants have a greater capacity in removing nutrients than wetlands without plants (Kanabkaew and Puetpaiboon, 2004) and nitrogen level of secondary treatment effluent can be reduced by cultivating plants in CWs (Rippingale and Smith, 1984). Submerged plants play an important role in removing nutrients and supporting heterotrophic microorganisms by providing high quality organic materials (Ozimek *et al*., 1993; Sinha *et al*., 2000 and Bastviken *et al*., 2005). H. *verticillata* have been used by Tanaka *et al*. (2006) at the end of an emergent plant wetland as an integrated system and proven that the effluent is more purified when submerged plants are arranged in series with emergent plants.

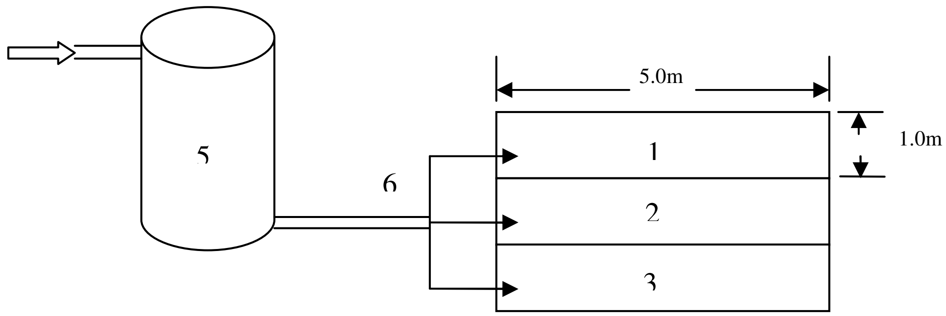
As described earlier, water reclamation require excessive removal of pollutants from wastewater before reuse it. In this regard, enhancing metabolism of heterotrophic bacteria involved in denitrification process is essential. Therefore, use of macrophytes (emergent, submerged or floating) is advantageous in CWs as they enhance the metabolism of heterotrophic bacteria by involving biological recycling, providing sites to attach microbes and suspended matter and providing organic carbon by plant detritus. Submerged plants are very sensitive to changing concentrations of nutrients (Ozimek *et al*., 1993) and the photosynthesis of submerged plants will increase the dissolved oxygen in water, retarding the denitrification. The use of coir-pith as the substrate in submerged plant systems might accelerate the denitrification by adsorbing part of nitrogen and providing some amount of organic carbon to water. The selection of substrate porous media is therefore important in removing especially nitrogen and phosphorous effectively. Accordingly, the testing of coir-pith as a substrate in free water surface CWs and finding out the ability of coir-pith on nutrient removal will be essential not only due to their availability in free of charge, but also very high capacity in absorption and adsorption than the other substrate materials, commonly used in CWs.

This study examined the ability of coconut coir-pith as the substrate, with H. *verticillata* as the submerged vegetation in free water surface CWs to remove residual contaminants from secondary treatment effluent or to use as a wastewater polishing technique where emergent plant system is not functioning well. The objectives of this study were to; (i) examine the effect of coconut coir-pith as a medium, on nutrient removal in tertiary wastewater treatment with H. *verticillata*. (ii) identify the best ratio of sand: coir-pith as a substrate material in CWs for optimizing the tertiary wastewater treatment.

Materials and Methods

Field experiment

The study was carried out at University of Peradeniya, Sri Lanka. Already constructed, rectangular lysimeters, each having the dimensions of 5 m, 1 m and 0.6 m in length, width and depth, respectively were used for the experiment (Figure 1, Figure 2 and Plate 1).



1. Lysimeter filled with sand only (L_1).
2. Lysimeter filled with coir and sand mixture (L_2).
3. Lysimeter filled with coir only (L_3).
4. Effluent from secondary treatment system.
5. Storage tank.
6. Distribution pipes to each lysimeter.

Figure 1: A schematic diagram of the experiment layout.

Each lysimeter was operated as free water surface wetland. The effluent from secondary treatment constructed wetland was used as the influent. The pipes were fixed from the secondary treatment wetland (sub surface wetland) up to the storage tank. Then a pipe system with valves was fixed from a storage tank to the each lysimeter. In addition, water depth control structures were fixed at the end of the each lysimeter bottom (Figure 2).

All the lysimeters were washed after removing existing plants and media in each lysimeter. Three types of media were used in lysimeters as the substrate. One was filled with only sand, another with coir only and the other was filled with mixture (1:1 by volume) of sand and coir. Each lysimeter was filled up to 10 cm height with the respective media. The lysimeter filled with only coir, after filling with coir-pith a layer of sand (9:1 coir: sand) was put on coir-pith

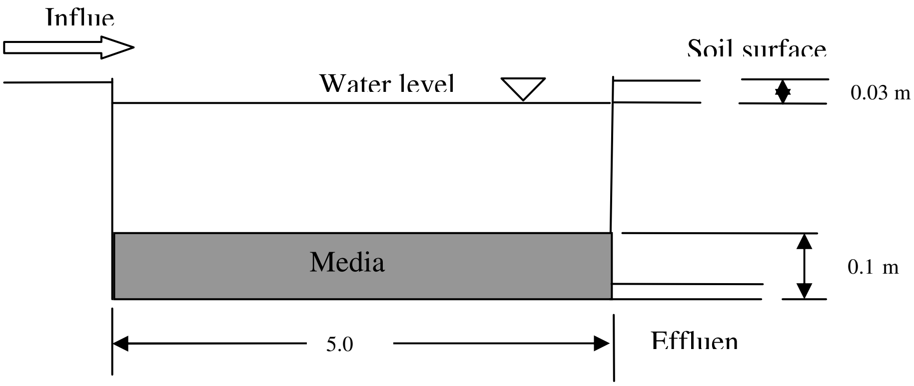


Figure 2: A longitudinal section of a lysimeter.

Plate 1: Lysimeters used for the study.

Submerged plant (H. verticillata) was used as the plant in the wetland units. Planting was done using 15 cm long strands of Hydrilla at the spacing of 10 cm x10 cm as three strands per each planting point. Just after planting, each lysimeter was filled with clean water for two weeks and plants were allowed to grow. Once plants develop their roots and branches, wastewater (effluent from secondary treatment wetland) was introduced to each lysimeter. Hydraulic retention time was maintained as four days. Flow rates of influents to each lysimeter as well as effluents were maintained by manipulating a valve system. Flow rate was monitored and adjusted once in two days in order to achieve a constant flow rate throughout the study.

The entire system was allowed to run for four weeks after introducing wastewater. Subsequently, the influent and effluent water samples from each lysimeter were collected weekly and transferred to the laboratory. The temperature was measured onsite using a thermometer (Kwality Research, 0-150^{0} C).

Conductivity and total dissolved solids were measured using the conductivity meter (ThermoOrion, model 145A). pH meter (Orion research longlyzer, model407A) was used to measure pH in water samples. The samples were analyzed for water quality parameters such as total suspended solids, nitrate nitrogen, total nitrogen, phosphate phosphorous, ammonium nitrogen, faecal coliform and five-day biochemical oxygen demand following standard methods (APHA, 1980).

Plant growth was monitored once in two weeks interval. Fresh weight, dry weight, length of the main stem, length of the longest branch and number of branches for a plant were monitored as plant growth parameters.

Laboratory experiment

In this study 5 L aquaria (buckets) were used. Different ratios of sand and coir-pith were used in this experiment. The selected media were placed at the bottom of each aquarium as total weight of the media to be 1000 g. The ratios of sand: coir-pith used in the experiment was 5:0, 4:1, 3:2, 2:3 and 1:4. Planting was done using 10 cm long strands of hydrilla as five plants per each aquarium and buckets were filled with clean water. Albert's solution was added in recommended amount as a nutrient supplement for plants. The mean individual plant dry weight of such strands of hydrilla was measured at the beginning of the experiment. Subsequently, the plant growth of each aquarium was monitored using dry weight of each harvesting.

Finally, data analyzing was carried out for the field experiment as well as laboratory experiment. The removal efficiency of each parameter was calculated using the Equation 1, based on the influent and effluent concentrations.

$$\eta = \frac{(C_{in} - C_{eff})}{C_{in}} X\, 100 \quad \text{..} \quad [1]$$

Where;

η = % removal efficiency

C_{in}= influent concentration (mg/L)

C_{eff}= effluent concentration (mg/L)

The relative growth rate (RGR) was calculated for each aquaria in each harvesting, using the Equation 2 and then average RGR was calculated.

$$RGR = \frac{(\ln X_2 - \ln X_1)}{(T_2 - T_1)} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{[2]}$$

X_1 and X_2 are plant dry weight at times T_1 and T_2, respectively.

Results and Discussion

The average temperature and pH of the influent were around 24^0 C and 6.0, respectively during the study period. The average pH of effluents from L1, L2 and L3 were 6.7, 7.0 and 6.4, respectively and the highest pH has resulted from L2 lysimeter which shows the highest plant density. Therefore, photosynthesis of submerged plants can be a reason to pH increment in effluents.

Nitrogen performance

Among the three parameters of nitrogen tested in water samples (NO_3-N, NH_4-N & total N), nitrate level increases in the effluents than in the influent (Table 1). That could be resulted from remaining nitrogen after nitrification process in each lysimeter. Vymazal (2007) have concluded that, when there is an enough oxygen concentration to enhance the growth of nitrifying bacteria, nitrification process takes place. Therefore, the increase of oxygen concentration of water column by photosynthesis of submerged plants may be a reason to high nitrate concentration and low ammonium concentrations in effluents.

The variation of average total nitrogen concentrations is shown in Figure 4. According to Figure 4, the highest TN removal efficiency has resulted from L3 while the lowest from L1. Therefore, not only plant growth effect but also the media adsorption of nutrients may result in a comparatively higher removal efficiency (>50%) in L2 and L3. The remaining TN in effluent water is neither in the form of nitrate nitrogen nor in ammonium nitrogen. This nitrogen might be in the form of organic nitrogenous compounds or nitrite nitrogen as they were not detected in water samples.

Jinadasa *et al.* (2005) conducted a study at the same site showed that the ratio of NH4-N/NO_3-N was high in the effluent from secondary wastewater treatment (SSF wetland).However, in this study, results are not similar and might be due to malfunctioning of the secondary treatment system resulting very low nitrate concentration of influent to this study than the ammonium concentration.

Denitrification may be taken place in wetland sediment and in the water where dissolved oxygen concentrations are very low and organic carbon is high. As a result of organic carbon consumption, in denitrification process pH increases (US-EPA, 1999). In this study, both the highest ammonium removal efficiency and the lowest nitrate concentration (Table 1) have resulted in L2. As well the highest pH also reported from the same lysimeter. Therefore, that is very clear to note that the denitrification has taken place effectively in L2.

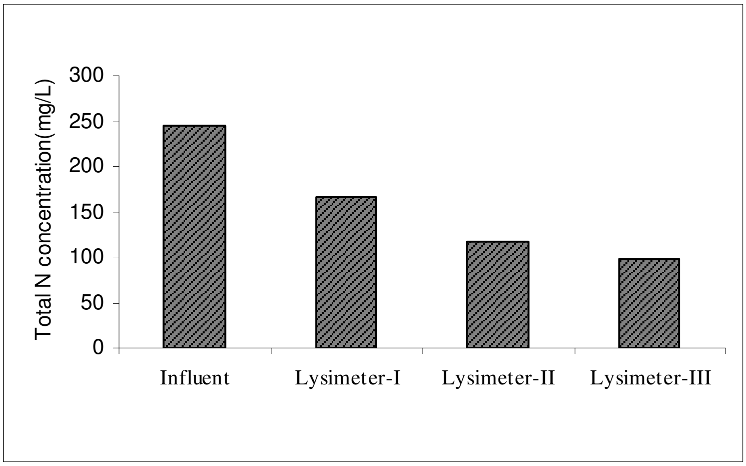


Figure 3: Average TN concentrations in influent and effluents.

Chang *et al*. (2006) have shown that ammonium is directly taken up by aquatic plants as the nitrogen source for protein synthesis and subsequent biomass production. Additionally, they have found that the uptake of nutrients, by using both floating and submerged macrophytes is the most important factor affecting the TN.

Phosphorous performance

Phosphorous in constructed wetlands occurs in different forms. The orthophosphate is the form that is utilized by the plants and algae. Phosphorous may be adsorbed to wetland substrate and sediments (Vymazal, 2005). In addition to plant uptake and adsorption by the substrate, peat/soil accretion, precipitation, fragmentation and leaching, mineralization and burial are the other transformations of phosphorous in wetlands.

The phosphate removal efficiency was higher at L2 and L3 than the L1. This could be resulted from assimilation, by dense submerged macrophyte community and the higher efficiency of coconut coir- pith in adsorption. The phosphate concentration in influent and effluents of each lysimeter is shown in Figure 4. However, phosphate removal was relatively higher in the three systems until the 35th day from the commencement of the water sample analysis, and has been dropped at the later stage of the experiment. But, even at the later stage of the experiment the removal of phosphorous is still higher (low phosphorous concentration in media) in L3 than that of the L1 which explains the higher adsorption capacity of coconut coir-pith over sand.

Table 1: The removal efficiencies of NO_3^- and NH_4^+ in each lysimeter.

Parameter	Influent	Lysimeter-I		Lysimeter-II		Lysimeter-III	
	Con. (mg/L)	Con. (mg/L)	RE%*	Con. (mg/L)	RE%*	Con. (mg/L)	RE%*
NO_3-N	0.34±0.2	1.18±1.0	-241.9	1.03±1.1	-199.9	1.08±0.7	-215.3
NH_4^+	40.88±9.7	9.22±10.3	77.5	2.86±1.3	93.0	4.49±3.9	89.0

* % Removal Efficiency

Jinadasa *et al*. (2005) have proved that phosphorous removal in CWs is not effective when hydraulic retention time is low. In this study, the removal efficiencies were in between 60-80% and that may be resulted from increase in contact opportunities between wastewater and substrate since the four days hydraulic retention time used in this study is comparatively higher than that has been used in previous studies.

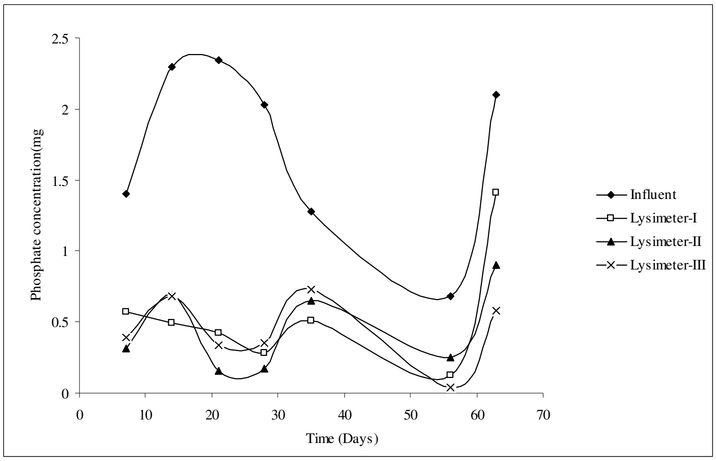


Figure 4: Phosphate variation of influent and effluents with time.

Faecal coliform performance

As illustrated in Figure 5, similar to other parameters, the highest removal efficiency of faecal coliform has achieved by L2. Coliform removal by L1 is much lower than L2 and L3. The high number of coliform in L3 than L2 may be due to dispersing of coconut coir-pith in L3. However, the results show the ability of coir-pith to remove coliform than the sand. Tanaka *et al*. (2006) have reported that there are many processes such as sedimentation, aggregation, exposure to biocides, antibiosis, predation, natural die-off and competition for limiting nutrients or trace elements are involved in removal of faecal coliform from wastewater.

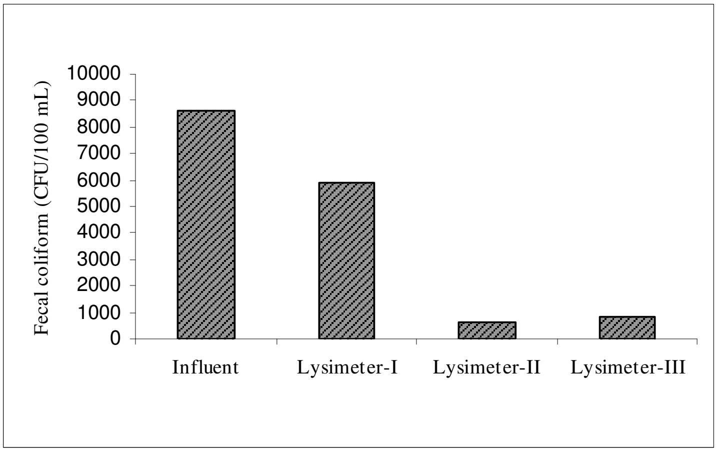


Figure 5: Average Faecal coliform variation in influent and effluents.

Removal efficiency of BOD_5, conductivity and total suspended solids (TSS)

Removal efficiencies for five-day biochemical oxygen demand (BOD_5), electrical conductivity and TSS in each lysimeter have recorded in Table 2. The highest removal of both BOD_5 and TSS has taken place in L2, with mixture of sand and coconut coir-pith (1:1 by volume) and the highest plant density. Microbial growth on the media surfaces and growth attached to the plant roots and stems reduces the soluble BOD_5. Even though there is a removal of BOD_5 from all the lysimeters, the removal efficiency has ranged between 25-50% of influent BOD_5. This could be a result from the decomposition of biomass, litter and sediment leading to increase in BOD_5 in water column (Kanabkaew and Puetpaiboon, 2004). At the same time, the results of the same study have proven that the removal efficiency of BOD_5 is increased by longer hydraulic retention time as it will remove more organic matter by increasing the interaction within the aquatic plant system. Further, the low removal efficiency of BOD_5 in L3 than that of L2 could be due to remaining of excess excreted organic matter by coconut coir-pith to water.

The highest removal efficiency of TSS has achieved in L2 might be due to decreasing of water flow velocity by hydrilla, which enhances the settling of particulate matter and the adsorption by the media. Sand has the less adsorption capacity than the coir-pith. However, still there is a removal of TSS which could be a result of adhering of particle to surfaces of plant stems and leaves.

The removal efficiency of electrical conductivity is found to be equal in three lysimeters (Table 2) regardless of the substrate used in each lysimeter. Electrical conductivity is caused by the dissolved ions in water, and the removal of these ions has not been varied with the substrate composition.

Table 2: Removal efficiencies of BOD_5, conductivity and TSS in different lysimeters.

Parameter	Influent	Lysimeter-I		Lysimeter-II		Lysimeter-III	
	Con. (mg/L)	Con. (mg/L)	RE% *	Con. (mg/L)	RE% *	Con. (mg/L)	RE% *
BOD_5 (mg/L)	17.9±9	11.4±6	36.2	8.2±4	54.4	9.7±3	45.6
Conductivity (µscm^{-1})	391±106	246±112	37.1	250±103	36.1	241±76	38.5
TSS (mg/L)	115.0±85	83.0±47	31.5	44.0±35	92.8	78.0±34	89.9

Plant growth performance

Variation of H. *verticillata* dry mass with time is given in Figure 6. As shown in Figure 6. dry matter has fluctuated with time in all lysimeters. Viz, plant growth has increased at the early stage of plant growth in L1 and L2. While it has decreased in L3 and almost all the plants in that lysimeter were died by the second week after planting. That may be due to some excretions from coconut coir-pith, later plants were grown well in coir-pith substrate as well. This emphasizes that the coir-pith should be conditioned by soaking before planting, in order to reduce stress to plants.

Although the dry weight of plants in L3 is greater than the other two, the highest plant density was observed from L2 where equal amount of sand and coir-pith was used as the substrate. That is the lysimeter which shows the highest removal efficiency for most contaminants. H. *verticillata* branches when plant reaches to the water surface (http://www.in.gov/dnr/invasive species/hydrilla.pdf.). The substrate of L3 was lifted up from the bottom of the lysimeter after the lysimeter filled with water. So that, the plants were reached the water surface, resulting more branches in L3. That was the reason to the highest plant dry weight in L3, though L2 had the highest plant density.

As shown in Figure 7, the maximum relative growth rate (RGR) was resulted in aquaria-III where sand and coir-pith was mixed approximately in equal amount (3:2 sand: coir-pith by weight). Even though it seems all the ratio of sand: coir- pith has given more or less similar growth, there were problems encountered when it was used coir-pith alone as well as sand alone in the field experiment. Viz, sand has no absorption, no nutrients and less adsorption.

Coconut coir-pith solely cannot be used in free water surface CWs as it is lifted up from the bottom of the wetland so as to dispersing the coir-pith, air trapping beneath the coir-pith. In this study, there were problems with related to that even though the ratio of coir-pith: sand was 9:1. So that, some nutrient removal mechanisms cannot be achieved though there is a better plant growth on coir-pith substrate.

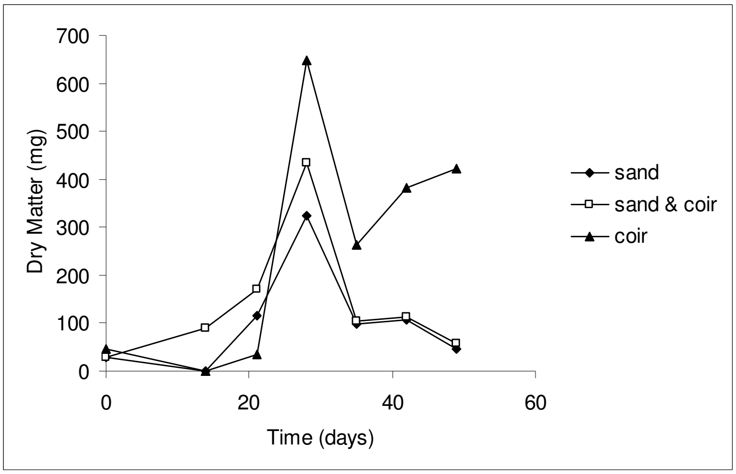


Figure 6: Plant (*Hydrilla*) dry weight variation in each lysimeter with time.

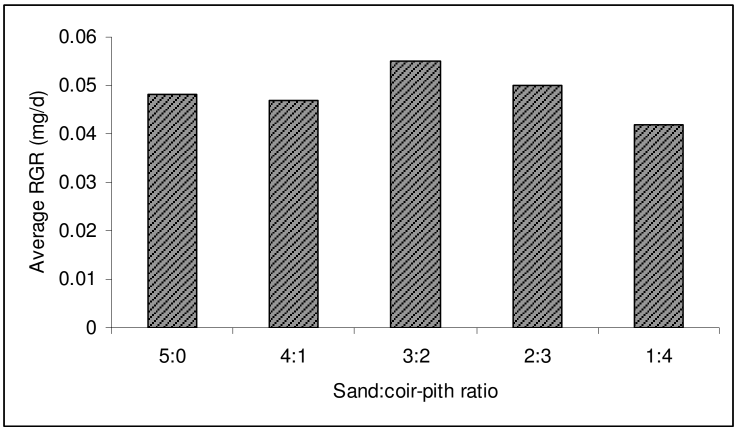


Figure 7: Average RGR variation in different ratios of sand: coir-pith Substrate.

Conclusions and recommendations

Conclusions

The experiment illustrated very evidently that the elevated activity in the wastewater reclamation at coconut coir-pith amended submerged wetlands. The removal of coliform, ammonium, biochemical oxygen demand and total suspended solids were revealed their maximum at the mixed substrate (1:1) than at individuals. The removal efficiency of NH_4-N, PO_4-P, BOD_5, Total coliform and TSS in L2, were 93%, 74%, 54%, 93% and 62%, respectively, which were higher than the other two lysimeters. However, there was no greater impact from the coir-pith introduction on the removal mechanisms of conductivity in the submerged systems.

Although the dry weight of plants in L3 is greater than the other two, the highest plant density was observed from L2 where equal amount of sand and coir-pith used as the substrate.

Recommendations

After some time the substrate used in CWs become saturated and therefore the performances of the system will be decreased. So that, need to find out the reduction of sorption performance of the mixture of sand: coir-pith over time.

The best ratio of sand: coir-pith was examined only for plant growth. It is important to test the best ratio of that for removal of nutrients and other contaminants, then for the combination of plant growth and contaminants removal.

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Lessons learnt from three tire hand pump maintenance system (3TMS)

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Abstract

The Hand Pump Tube Wells (HPTWs) programme implemented during the International Drinking Water Supply and Sanitation Decade of 1980 has been playing a vital role to supply drinking water for both rural and semi urban communities in the dry zone. The 3-Tier Maintenance System (3TMS) in which the consumer societies, local authority and the National Water Supply and Drainage Board (NWSDB) are involved in maintaining the tube wells has been able to ensure the sustainability of the HPTW programme by ensuring active participation of the three stakeholders in maintaining the tube wells. 3TMS minimises the maintenance cost of HPTW since the local authority and the consumer societies are involve in the maintenance. Furthermore, it creates a sense of ownership among the consumers and helps to sustain the smooth functioning of tube wells.

Background

The extensive utilization of groundwater resources to provide drinking water to rural communities in Sri Lanka began in late 1970 s. During the International Drinking Water Supply and Sanitation Decade (1981 – 1990), Sri Lanka utilized various donor assistance such as GTZ, DANIDA, FINIDA, NORAD, UNICEF to implement HPTW programmes all over the island. As a result, there are a large number of tube wells installed to meet the issue of drinking water in the communities in the dry zone of Sri Lanka.

However, in later years, the maintenance aspect of these wells became a problem. The problem relating to the maintenance of these HPTW was more visible at the beginning of the decade. Considering this situation in 1995, the Government of Sri Lanka (GOSL) passed a cabinet paper to cover the following aspects.

- Prioritization of requests for HPTW
- Resources allocation for HPTW drilling pogramme
- Provision with HPTW
- Maintenance of HPTW

Objective

The objective of this paper is: (1) Explaining HPTW maintenance policy and implementation process of 3TMS; (2) Elaborating the national level achievements / lessons learnt in HPTW maintenance policy.

Policy on maintenance of HPTW

HPTW involved in periodical maintenance due to wear and tear of parts during the operation. Hence, a properly organized setup at community level was necessary to maintain the HPTW in order to render its intended services to the community and to ensure the sustainability. This maintenance system is named as Three Tier Maintenance System (3TMS) and decided as follows;

First tier – *Consumer societies*

The respective community should organize a consumer society to assist the local authority in the maintenance of HPTW. This is the foundation on which the 3TMS rests and the consumers themselves represented in consumer societies (societies intended for maintenance of facilities). The voluntary caretakers are selected from the community to look after the smooth functioning of the well. At the initial implementation stage, the caretakers were given basic class room training as well as on the job training on the aspects of preventive maintenance of the HPTW. Supplementary training for replacements has to be done by the Technical Officer of the Local Authority [Pradeshiya Shabha (PS)] who too is trained in the same disciplines. The most important duty of the caretaker is to keep the PS water mechanic informed when a underground component of the pump is mal- functioning.

Voluntary contribution of SLR[3] 500 (US$ 4.5) per well from a family is collected as a basic annual maintenance cost for the users out of which SLR 200 (US$ 1.8) should be paid annually to the respective PS as maintenance funds. The balance of SLR 300 (US$ 2.7) is to be deposited in the society bank account to spend for replacing the spare parts such as chain, cup washer and handle bearings when ever they are required.

Second tier – *Local authority (Pradeshiya Shabha)*

PS acts as a divisional level maintenance body and it has direct links with the two tiers in the integrated maintenances system. Each PS has been provided with the following basic facilities to maintain the system under the institutional strengthening programme of the project.

- Mini workshop
- Basic tools for hand pump repairs
- Transport facility for HPMU
- Classroom and on the job training for Technical Officers and Hand Pump mechanics
- One year stock of essential spare parts

However, it has been realized that the Local Authority doesn't have capacity to undertake major improvements, major repairs or installation of new facility. (e.g.

[3] Sri Lankan Rupees

well flushing, new drilling for dry wells, etc.). On the other hand, bulk purchasing of spare parts from manufactures is not feasible at this level, since the annual requirement is limited.

Even though, the PS is the key administrative body at the divisional level, its manpower and financial resources are limited and at the same time as the Local Authority, it has to carry out multi disciplinary activities according to its legislations. Hence, it has certain limitations to pay high priority for drinking water supply. However, PS has been vested with responsibility (by its legislation) to provide drinking water supply for the incumbents of the respective division.

Third tier – *National Water Supply and Drainage Board (NWSDB)*

The National authority of drinking water supply acts as the third tier under this system. The NWSDB has a decentralized set up for maintenance even at the divisional level.

Attending for major breakdowns, cleaning of wells, installation of new facilities, bulk supply of spare parts, monitoring, evaluation, feed back, research and development are key functions which come under the responsibility of the third tier. However, a strong link is vital between the second and third tier in order to implement the system effectively.

Figure 1 explains the implementation system of 3TMS. The process of the system is revolving as follows. The PS uses its funds for purchasing spare parts from NWSDB. NWSDB purchases spare parts in bulk from manufacturing companies annually to meet the requirement of all the PSs. NWSDB provides spare parts at cost to the Local Authority and it provides spare parts at cost to the consumer societies.

Lessons learnt from 3TMS

In consideration of socio economic factors of rural communities in Sri Lanka, HPTW is accepted as one of the most feasible options to provide potable water to the rural sector specially in the dry zone which accounts for nearly two third of the country. Geographically, these areas are mostly with flat lands, agricultural based and identified as low population densities.

Existing water sources of these areas are seasonally activated. Similarly, during more than eight months of the year, the people experience dry climatic situations in these areas. During this period, water level of some HPTW depreciates and creates conflicts within the community in collecting water. According to the 3TMS policy, community participation has been supported to manage social issues to minimise conflicts and help proper water management during drought periods. User groups involve in looking after the HPTWs discuss within the respective user group about operation, maintenance, management and controlling over HPTW according to the 3TMS. It helps to strengthen the 3TMS policy in collaboration with the PS and NWSDB.

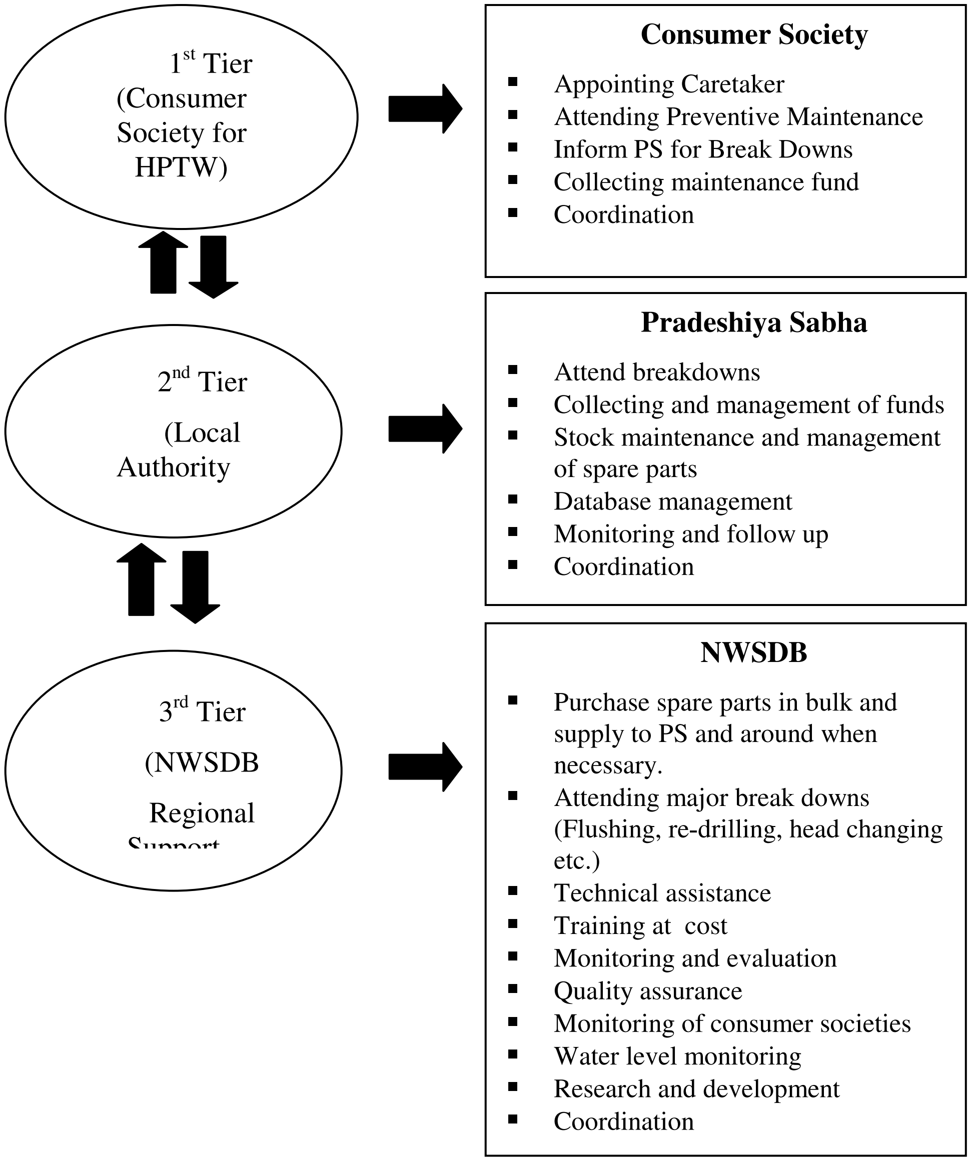

Figure 1: Implementation flow chart of 3TMS.

Water quality also has some variations. Hardness, calcium, fluoride and iron are the most significant issues related to the groundwater quality in the dry zone area. Hardness, calcium and iron could be identified on taste. Fluoride is slightly different and it could be identified only on testing. In some wells, though the water quality is not up to the standard, consumers use these wells for other than the drinking purposes like washing and bathing due to water scarcity is more acute in dry zone compared to the wet zone. Long term sustainability of HPTW is very essential in reducing water scarcity.

Successfulness of 3TMS depends on repair cost and downtime. It is a good lesson that community involvement in maintenance of HPTW leads to reduced repair cost and downtime.

Other important lesson learnt from the system is that sector bodies contribute more attention to the maintenance process of HPTW. It helps the sustainability of HPTW. In addition to this trained care taker is responsible for preventive maintenance activities, user groups are responsible to ensure user participation for better practices and utilization of HPTW. It directly affects the appearance, better environment and long term sustainability of HPTW.

Collection of maintenance funds has contributed to the assurance of establishing proper maintenance. It ensures the local authority involvement for maintaining the well.

Table 1: Present status of implementation of 3TMS in Sri Lanka.

No	**Province**	**Districts**	**No of PS Divisions**	**No of HPTW**	**No of PS Divisions implemented 3TMS**	**No of HPTW handing over to PS**
01	Western	03	33	1518	6	265
02	Central	03	34	4150	29	3250
03	North Central	02	24	7130	21	6322
04	North Western	02	27	4507	22	3875
05	North East	07	33	823	1	489
06	Sabaragamuwa	02	22	1132	None	None
07	Sourthern	03	29	2375	10	1075
08	Uva	02	23	3870	23	3355
Total		**24**	**255**	**25505**	**112**	**18,631**

3TMS minimises the maintenance cost of HPTW especially due to the involvement of PS and consumer societies in maintenance activities. This system creates a sense of ownership of the HPTW among the user community and it is a greater help to preserve the facility for their own benefit. It also helps to involve community participation in the HPTW maintenance programme.

The various types of HPTW installed in the country by various implementing agencies have given rise to maintenance issues due to the lack of wide variety of spare parts that are required during the last three decade. Under 3TMS, once the HPTW is handed over to the PS, the NWSDB will attend to rehabilitation work and standardize the HPTW to India Mark II or III hand pumps4 to facilitate proper operation and maintenance of HPTW.

Monitoring and evaluation

Selected 20 Nos. HPTW were monitored in Thumpane PS area in Kandy district, where 10 Nos. were maintained under 3TMS and other 10 were not maintained under this system. Five main criteria were taken into account as follows;

1. Whether the HPTW is functioning or not
2. Existence of consumer society
3. Financial commitment by user group
4. Availability of caretaker
5. Level of maintenance

Table 2: Present status of selected HPTW under 3TMS.

No	Well No	No of Families	Whether it is functioning or not	Existence of consumer society	Status of paying annual charges to PS	Availability of active caretaker	Level of maintenance
1	3041	10	Yes	Yes	Yes	Yes	Good
2	6129	75	Yes	Yes	Yes	No	Satisfactorily
3	3024	20	Yes	Yes	Yes	Yes	Satisfactorily
4	3029	100	Yes	Yes	Yes	Yes	Good
5	1161	25	No	Yes	No	No	Poor
6	1669	07	Yes	Yes	Yes	No	Satisfactorily
7	3838	20	Yes	Yes	Yes	Yes	Good
8	3536	25	Yes	Yes	Yes	Yes	Satisfactorily
9	6131	15	Yes	Yes	Yes	Yes	Good
10	6100	20	Yes	Yes	Yes	Yes	Good

[4] This ensures the availability of spare parts for maintenance of the pump

Table 3: Present status of selected HPTW which are not under 3TMS

No	**Well No**	**No of Families**	**Whether it is functioning or not**	**Existence of consumer society**	**Status of paying annual charges to PS**	**Availability of active caretaker**	**Level of maintenance**
1	3141	15	No	No	No	No	Poor
2	3023	12	Yes	No	No	No	Satisfactorily
3	3145	20	No	No	No	No	Poor
4	1158	12	No	No	No	No	Poor
5	1159	15	Yes	No	No	No	Satisfactorily
6	0020	30	No	No	No	No	Poor
7	6096	20	Yes	No	No	No	Satisfactorily
8	3028	18	No	No	No	No	Poor
9	6048	15	Yes	No	No	No	Poor
10	3034	20	No	No	No	No	Poor

The results of this study reveal that the establishment of 3TMS greatly helps to proper functioning and maintenance of HPTW. Further it is also observed that malfunctioning and poor maintenance in HPTW which are not operating under this 3TMS.

Lack of community participation and poor involvement of local level administration in supply and maintenance of HPTW lead to failure of hand pumps in various areas in the country. The 3TMS has ensured the community participation and community contribution towards the successful implementation of the hand pump programme.

Conclusion

According to the above findings it is realized that HPTW maintenance policy has fulfilled the needs of drinking water supply to the communities. It also helped to minimise water borne diseases in the dry zone areas as the water is free from pathogens. Similarly, this system also has trained the community to manage pubic resources. Sense of ownership and mobilization of the community have contributed to enhance the community empowerment. Standardization has been conducive for establishing and smooth functioning and maintenance of HPTW. 3TMS has contributed to develop social capital of the entire society.

Number of the evaluations carried out by national and international agencies have proved that this system is more appropriate for the sustainability of HPTWs. Thus, the countries which involved in providing drinking water through public HPTWs can learn lessons from this experience and adjust their policies and move on to sustainable HPTW maintenance systems with community participations.

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Community planning for wastewater management in low income communities

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Abstract

Although findings from participatory planning of sanitation interventions have consistently mentioned the importance of community involvement to ensure sustainability, there is still inadequate practical knowledge of the approaches to take and the process by which this is to occur. Research from a low income community in Kurunegala, Sri Lanka illustrates the importance of building the capacity and ownership of the community to address their sanitation problems. Lessons from this action research conducted by COSI with a community based organization (CBO) shows that training to build skills in good organizational practices, including planning and financial management, has an extremely positive impact on latrine construction, water supply initiatives and hygiene practices. Transparency and inclusion were stressed in the planning and efforts were made to include all groups and to keep dialogue open with the wider community. This diffused tensions, for example when the CBO was accused of misusing funds. The work also highlighted the groups within a community that are more likely to become physically involved in building, which provides lessons on how to include non-participative groups. It also showed the disruptive behaviour of individuals both within and outside the community. To address the hygiene issues the COSI team and the CBO mobilized smaller groups of women and children, with whom they undertook a number of educational activities and follow-up monitoring. The results showed that most of the children are aware of good hygiene practice but that they are not practicing what they know – games that highlighted their lack of daily hygienic practices had some positive results in changing this. Women who slipped back into unhygienic practices could be much more easily convinced to take them up again because of their increased knowledge and discussions in their small groups. The knowledge and lessons from this work are useful for NGOs and other practitioners implementing community-based participatory plans for sanitation or who are interested in practical examples of approaches to strengthen CBOs and win the approval of communities to ensure sustainable interventions.

Introduction - Sanitation Interventions and Participatory Approaches

According to UNICEF's report on Water and Sanitation, about one-third of Sri Lankan households have no access to sanitation and another quarter have no access to safe drinking water (UNICEF accessed 12.06.08). This lack of basic sanitation[5] and safe drinking water[6], as defined by the World Health Organization (WHO), needs to be addressed as it has far-reaching impact on the socio-economic condition of Sri Lankan society. The requirements also illuminate the need to increase the accessibility[7] of water points which is another aspect of sanitation and hygiene interventions.

What is needed for a successful sanitation intervention in communities is a system that is sustainable from a social, as well as an economical and environmental perspective, which will vary according to the community or region in which the interventions are being implemented. In providing what may be considered a technically well-functioning system through a top-down approach, practitioners and implementers might risk ignoring the so called "smaller issues" related to such interventions that lie at community level. Although as minuet as they seem these are important components of ensuring the sustainability of a sanitation and any other social and health intervention programme.

In relation to these issues, this paper discusses the lessons learned from the Wastewater Agriculture and Sanitation for Poverty Alleviation in Asia (WASPA Asia) Project, which is funded by the European Commission under its Asia Pro Eco II Program and is being undertaken in Sri Lanka and Bangladesh by a consortium of partners. WASPA Asia aims to involve a wide range of stakeholders in developing and testing solutions for sanitation and decentralized wastewater management, and mitigation of health risks from wastewater use in agriculture.

In Sri Lanka the project is working specifically with a low income community in Kurunegala City, called Wilgoda, which is home to around 120 families. The interventions in this area related to improved sanitation and hygiene and provide important lessons for other organizations working in densely populated peri-urban areas, where land ownership is insecure and local government provision of infrastructure is limited.

Therefore, the findings will be particularly useful for NGOs and other practitioners implementing community based participatory sanitation initiatives, and who are interested in practical example of approaches to strengthen CBOs and win the approval of communities to ensure sustainable interventions.

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[5] *Basic sanitation* is the lowest-cost technology ensuring hygienic excreta and sullage disposal and a clean and healthy living environment both at home and in the neighborhood of users. Access to basic sanitation includes safety and privacy in the use of these services. Coverage is the proportion of people using improved sanitation facilities: public sewer connection; septic system connection; pour-flush latrine; simple pit latrine; ventilated improved pit latrine.

[6] Safe drinking water is water with microbial, chemical and physical characteristics that meet WHO guidelines or national standards on drinking water quality;

[7] Access to drinking water means that the source is less than 1 kilometer away from its place of use and that it is possible to reliably obtain at least 20 litres per member of a household per day

Background

Participation, defined by the World Bank (1996) as "a process through which stakeholders influence and share control over development initiatives and the decisions and resources which affect them.", is increasingly recognized as the most effective way to ensure effective use of facilities and sustainability of infrastructure or improved behaviour. This was therefore the approach adopted by the WASPA project team. Through participatory approaches a community can:

- Express and analyze the realities of their lives;
- Plan for themselves what action to take to change the situation;
- Monitor and evaluate the results themselves; and
- Develop an understanding of how to take responsibility and leadership for the development of the community.

Unsuccessful sanitation interventions have shown that non-participatory methods often fail to fully take account of the initial problem as perceived by the community and ultimately impose solutions that do not necessarily address their needs. Some projects have not involved the local community at all in development activities, which results in community members being ill-equipped to fully understand the nature and rationale of the commitments they are being asked to make, which means that in practice they are unable to fulfil them. By contrast, it has been found that where communities have been involved, projects have a better chance of surviving through shocks, as the commitment is there to ensure that the project does not fail. The Water Engineering and Development Centre (WEDC 2001) states quite clearly that experience has shown that "In the area of sanitation, it may well be the case that interventions reliant upon behaviour change may fail if the community was not involved in designing these. However, when communities are involved, such messages are much better understood and are therefore taken on board. A secondary benefit is that members of the community will subsequently be better placed to act as change agents."

In participatory approaches, steps are undertaken collaboratively with relevant stakeholders. Participatory techniques, methods or approaches have the ability to generate constructive collaboration among stakeholders who may not be used to working together, come from different backgrounds, or have different values and interests. Such methods have been adopted by the WASPA team in Kurunegala to establish participatory planning and decision making with appropriate stakeholders for the development of a participatory sanitation approach for WIlgoda.

Methodology

Sanitation assessment

A basic household survey was used to collect general information on demographics and infrastructure in Wilgoda, which was followed by transect walks, including an observations check list that covered public places, common toilets, bathing place, and areas along the canal. Detailed interviews were conducted with 10 households in Wilgoda. Secondary health data were obtained from the epidemiology unit of the Provincial Health Department (PHD), the Malaria Control Unit and the Filariasis Control Unit in Kurunegala. The major areas of assessment included:

- The sanitation facilities and waste disposal in the area;
- Access to these facilities for different groups in the community;
- The use patterns by different groups in the community over time;
- The hygiene practices of groups in the community and the enabling factors for hygiene; and
- The health status of community members, particularly for water-related health risks.

Wilgoda Pura is the housing scheme for the Municipal Council (MC) laborers and covers approximately 5 acres. The community of Wilgoda has been identified as an urban low income community that lacks sufficient basic sanitary facilities and hygiene behaviour. Although the land and houses belong to the Kurunegala MC, several informal dwellings have been established in and around the line houses over the years and the population of the settlement has increased. At present, there are 119 houses[8] including informal dwellings, which are home to a total of 587 individuals including 407 adults (Nishanka *et al*., 2006). The majority of the community is illiterate and one of their main sources of income is daily wages received through unskilled labour.

The sanitation assessment was initially undertaken to capture the extent of sanitation problems, identifying knowledge gaps, and to help define activities that could minimize the impact of wastewater on the health of the inhabitants and downstream communities. This survey illuminated the fact that the existing health and hygiene situation of the Wilgoda community was not of an acceptable standard. This was partly due to inadequate infrastructure and provision of basic facilities, along with what appeared to be apathy on the part of the community to improve the situation. Discussions and observations suggested that the community as a whole was not active in working together to improve their environment or facilities, except within their homes. This was not surprising given the general level of cohesion within the community and it is a common misconception that because people live in close proximity they are "friends" and will be willing to work together for the common good. Nevertheless the assessment identified several individuals who were both influential and committed, and who possessed a strong desire to work with the WASPA team to address some of the issues that were highlighted by the study.

Observations of community behaviour also showed that they have some knowledge of hygiene practices but many are not clear on their consequences. For example, everyone who was interviewed said that they wash their hands before taking a meal but only a small percentage wash their hands after a meal. Most also

[8] This has increased from 114 in the 2006 survey (Nishanka *et al*. 2006).

wash their hands after using the toilet and over half do so before they prepare food. Most of these people use soap, and explained that they wash their hands to reduce the spread of disease. Most adults and children in the households interviewed use slippers when they go to the latrine. Many people share towels within the family but children usually have their own towel.

The external environment was not very clean, as houses are closely clustered and there is no ownership of the immediate surroundings. Common places were not kept clean and there was debris such as shampoo and soap packets all over the area, as well faeces. In contrast, the inside of the houses were observed to be clean. Sanitary practices of latrine usage, personal hygiene, protection of drinking water wells and solid waste management all needed to be improved.

A few households in the Wilgoda area have piped water (20%) but most use three common taps (75%) paid for by the MC. Some also use a shallow well and tube-well but they are not in good condition. All wastewater from the houses is drained to the Wan Ela through the drainage lines but after the rains the water tends to collect in the uneven spaces on the ground. The already polluted environment becomes worse at this time, and foul smells pervade in the area; this is very unhygienic for the community members.

The baseline survey documented 31 latrines that were privately owned and built by the municipality. A further eight shared-facilities were built by an NGO for the line houses. According to the respondents the public facilities were used by 78 households (414 people). However, during the social mapping of the area 23 public and 36 private latrines were noted. Of these, 14 are very old (Nishanka *et al*., 2006). The latrines have either septic tanks or uncovered pits. Pits from the public latrines appear to be located too close to the canal (<10 m distance). When the latrines are full they are emptied using the MC gully-suckers, but there are complaints that they are not emptied properly, leading to overflowing, which is unpleasant and attracts flies.

The public latrine maintenance and cleaning is shared by community members, with an understanding that three households are responsible for one latrine. It was noted that the 10 new latrines are kept locked by the households responsible for maintenance and only used by specific households. These latrines were observed to be clean and washed. The old latrines were not locked and in some cases the doors were broken. They were badly maintained with urine and faecal matter on the squatting pans and on the concrete surrounding the latrine. The older latrines were in a much worse condition than the new ones. No water or containers were seen in the public latrines: water is carried there by those going to use the latrines. Soap was also absent.

Privacy is an issue, especially for women as the latrines are not gender segregated. Usually, there is a rush in the mornings and shared facilities have long queues. At night, some people use polythene bags to defecate in; these bags are thrown into the canal during the day earning themselves the name “flying toilets”.

The detailed interviews showed that some people who use the public latrines use other places for defecation and urination at night. Children often use the canal banks to defecate and the compounds around the homesteads to urinate.

Planning potential solutions

The issues identified in the study through a combination of observations, focus group discussions, household surveys and follow-up interviews, provided evidence of the following problems:

- Facilities in Wilgoda need to be improved including access to water and latrines. Gender Issues must be considered in any such plans.
- Cleanliness of latrines could be improved through an education campaign.
- Hygiene education appears to be important in order to reinforce how essential good practices are.
- Solid waste management is an issue.
- In terms of health, mosquito vectors are a problem and need to be controlled by removing vessels that can collect water and by improving the flow in the canals.

In order to provide feasible solutions to these issues it was vital that the community become more involved. So far their involvement had been limited to describing the constraints that they faced as residents in Wilgoda but they needed to be provided with the opportunity to actively engage in addressing these constraints. Community mobilization and capacity building were therefore seen as an essential next step. These were expected to be achieved through:

- Strengthening the existing CBO, the "Wilgoda Environment Society", which had been developed some years previously by another project;
- Developing a Village Action Committee (VAC) linked to the CBO to take responsibility for sanitation related activities that might be conducted in Wilgoda; and
- Creating a new Environment Society for children in order to encourage good hygiene behaviour and sanitation practices.

The CBO therefore became one stakeholder group in a multi-stakeholder platform that was facilitated by the WASPA project. This group of community members and government officials were brought together to develop a participatory action plan (PAP) based on the survey findings.

Implementation of the work plan

Building the Capacity of CBOs

The Environmental Society of Wilgoda is a community based organization (CBO) that was established about a year ago by SEPA Foundation and Practical Action (PA). Although the society existed when WASPA came to the community it did not function well without the support of previous project team, therefore, with the agreement of SEPA and PA, the WASPA team worked with the CBO to strengthen them so that they could operate as an independent unit.

In this process the Village Action Committee (VAC) of Wilgoda was formed by WASPA team. The VAC, which is a group of 5-7 individuals within the CBO, is an entity that comprises of prominent and active members of the CBO and other people from the village who are interested in its development. The intention was to have active and enthusiastic participation for all the activities conducted in the Wilgoda line houses and to build the capacity and the ownership of the community. It was necessary to form this group in addition to but linked to the CBO to take specific responsibility for sanitation related interventions, while the entire CBO worked on a variety of activities.

The result of these efforts is that at present the Environmental Society of WIilgoda is able to organize and coordinate their meetings as and when the need arises and the members, along with their president, seem to be more active in the meetings. There is also increased confidence in the members and they are all willing to speak up at meetings. They are now capable of handling finances and bank transactions as a registered CBO; and have improved legal recognition as both the president and the secretary maintain a seal on behalf of the society. This has come about because of the activities to improve the facilities in Wilgoda which are discussed below.

Despite the positive changes there are still some problems: the CBO has been facing issues relating to leadership; and team spirit has been declining. The project team feels that this is due to the weakness of the fast-track establishment of the society and accusations from the community, which has made them despondent as they were trying so hard to do good for their community. The community basically accused the VAC team of misusing the money provided by the project to build latrines. Fortunately this particular accusation could be addressed because they had been taught to keep good accounts and a meeting was called in which the VAC invited anyone with an interest to check their account books in which all financial transactions were recorded in detail.

At present the project team is working hard with the CBO to strengthen them and enable them to deal with similar issues if they arise in the future.

Improving Sanitation Facilities

As the survey revealed that there are 14 shared toilets in a poor condition, the WASPA project planned to remove and replace the damaged squatting pans, and raise the floor level. The septic tank was emptied using the MC gully sucker (this has not been done for a long time and required three attempts). With the technical assistance of the MC Public Health Inspector (PHI), the walls were raised to increase the capacity of the tank and to prevent it from overflowing in the monsoon season when rainwater enters the tank. The two water taps near the latrines were also repaired and a street lamp was constructed to improve security for anyone wishing to use the latrines at night. Drainage was also improved near the taps by making a concrete base sloping towards the street drain.

In order to upgrade the existing communal latrines the WASPA project team began their mobilization efforts through the CBO and VAC. During the first meeting the CBO stated that they were willing to support construction by providing masons and unskilled labour from the village. A date was fixed to obtain a quotation for goods from local hardware stores and responsibilities shared among the VAC.

Further meetings were held to discuss the quotes and labour, and it was decided that a "shramadana" (voluntary contribution of labour) campaign should be organized to clear the proposed construction site. It was agreed that 16 communal toilets should be constructed in two sets and that each toilet should be numbered and assigned to four families who would use them and maintain them. The toilets were assigned to families who were already using the existing set of latrines. The assignment was based on groups of relatives or friends. These families are generally neighbours to each other. This was seen as the best possible method, as the responsibility of cleaning and maintaining the toilet is shared among a group that has better interaction.

Nevertheless it was later observed that some of the community members wish to have toilets that are assigned based on gender. Therefore the feasibility of both ideas is being taken into consideration at the moment.

A bank account was opened at the local Sanasa Development Bank in the name of the CBO to enable them to manage their finances. The first cheque was handed over to the CBO and their Secretary, who is one of the few literate people in the village, was put in charge of the keeping accounts of every financial transaction. She was further advised on how to keep and maintain the records, and the importance of these records for transparency.

The villagers produced skilled and unskilled labour as promised and it was suggested that the families that had been assigned latrines should be responsible for constructing them as well as maintaining them.

The only real problem faced in constructing the latrines was the poor quality of some of the construction materials, particularly the cracked squatting pans which were a waste of time and money. With the support of the WASPA project officers, the CBO and the VAC managed to exchange the damaged squatting pans for new ones, although the shop keeper appeared to be surprised to have issued damaged goods.

The issue with the quality of the goods arose again when it was found that some of the brand new door locks that were purchased were decaying. It appears that the merchants seem to sell low quality goods and take advantage of this community because they are considered to have a 'low position' in the society. Often dubbed "illiterate" and "useless", the Wilgoda community is looked down upon by others and is vulnerable to the cruelty of others. In such instances, the only action they take is to seek the assistance of the project team. However, more sustainable solutions need to be sought to this problem.

Another impediment was that people became bored of helping when the work continued for a long time and the VAC had to really push them to complete the job. It was interesting to see that women were very active in the process, even lending a hand in masonry and it was a pleasant surprise to observe that some of the women who helped were not even direct beneficiaries. Only a few men outside the VAC provided labour as they are not really interested in engaging in labour on a voluntary basis. The women were definitely more active in contributing labour than men. The men also engaged in disruptive behaviour, such as defecating on the doorsteps of the latrines, that created an unpleasant working environment for the masons, the VAC and the project team. This made the masons give up their work and leave, so that the CBO had to look for new skilled labour. In order to put an end to such unruly behaviour, the WASPA team called a CBO meeting, where they expressed their concerns about the impact of such disruptive behaviour to the construction work as well as the development activities of the community by WASPA. The members were expected to carry this message to the other members of the community.

Water Supply

Although Wilgoda had a water supply from the MC, only a few families had proper water supply facilities in their homes. Those who did not have water supply had to make use of a couple of water taps, a tube-well and a dug well for all household purposes including drinking, bathing and cooking. The taps were situated in unhygienic and polluted places, and there was a clear need to provide an adequate and suitable water supply to the majority of the community.

To address this, the project team fixed a rope pump to the dug well, which enabled community members to draw water without much difficulty, which they use for bathing and washing clothes. It was observed that there was good participation among villagers in fixing the pump and therefore construction took place within one day. The well was also covered in a net to prevent mosquito breeding. After construction children were found to be using the water and washing frequently. The tube-well was also upgraded and the taps replaced and the area around them made more hygienic.

Improving hygiene behaviour

With the improved water supply and sanitation facilities in Wilgoda it was necessary to ensure that they would be maintained and that the community would receive maximum benefit through good hygiene and environmental sanitation practices. The target groups for these activities were mothers and children because in Wilgoda it is mainly the women who are responsible for hygiene and sanitation, and because it is women that suffer most due to the lack of access to sanitation facilities.

The target groups needed to be provided with knowledge about appropriate hygiene practices and then encouraged to make them part of their daily lives.

It was decided that a variety of activities would be undertaken with these groups including: educational sessions for students; formation of mother's groups and a children's environment club.

Working with women

As far as hygienic practices are concerned, most community members are aware of basic good practices such as hand washing, and kitchen and toilet cleanliness, but they are not practicing them fully. The project team's intention was to develop a closer acquaintance with the women of Wilgoda so that they could create awareness and develop good hygiene practices among them, which would be passed onto children through the mothers.

It was observed that the unemployed women were reluctant to attend meetings in a formal set up and that their free time to participate in such activities also varies. Hence, a number of small groups of women were created among neighbours. This way a group of 5 to 8 people get together during a given day and a time on a weekly basis to have an informal discussion session with the project officers on how to improve their existing hygiene practices, to ask questions and to clarify their doubts. By directing the flow of the informal conversations toward hygiene practices, they came out with common problems they face daily. The major complaint was the lack of common latrines and the problem of wastewater, as there is no sewage system. They also expressed the difficulties faced when fetching water from the taps and wells and that bathing and washing areas are in open common place. They also complained that they are often disturbed at night by drunkards.

The project team now experiences that the women are expressing themselves better than they did before the project started and that for some women further health education sessions should be conducted. The project team observed that many houses that are preserving hygienic practices suggested to them up to an expected level and that those who are not paying so much attention to hygiene can be quickly made aware of the fact.

These gatherings do have their difficulties especially when some of the participants fail to attend the meetings regularly. There are many interruptions from those who pass by and their family members, but it is gratifying to see that most of them do show an interest in taking part.

Formation of Children's Environmental Club

The children of Wilgoda are not school children as most of them leave school at an early age. The boys often engage in illegal activities and girls are more interested in getting married. Therefore they are not particularly interested in education about sanitation and even the few senior students who continue schooling are not willing to join in educational sessions.

The project team was however able to hold one sanitation program for them through a short story on open defecation. The participation was satisfactory and most children who participated were between the ages of six to ten years. Although it proved difficult to control them, they responded to the questions asked by the senior project officer quite well. The story, which was based on their own background, made them feel slightly embarrassed and they responded by laughing but they clearly understood the message.

Due to the positive reposes received through this session, the project team decided to take a step forward and establish a Children's Society, which would enable them to interact more with the children in the future. For this the project team extended personal invitations to the children to attend the first meeting to form the society. The children who participated were still school pupils. Among them there were 10 older children who seemed to be responsible and active, and were therefore appointed as officers of the organization. The inaugural meeting was brought to an end after a few songs were sung by some of the participants. It was decided that this society would gather every Thursday.

The appointed leaders proved to be very resourceful and encouraging in gathering and controlling children for meetings. On their third meeting they played a hygiene game with the project team. The game was based on a train and stations. There were five stations named: teeth station; face station; nails station; and hair station, where every passenger was checked by the station masters before proceeding to the next station. The station masters provided each passenger with a piece of card at every station; a green card for a good condition; a blue card for a normal condition; and a red card for a bad condition. Finally the passengers counted how many of each card they had received and the project team advised them on the value of these cards and that everybody should try to acquire green cards next time.

In order to enhance their leadership skills and talents, the project team invited the children to present songs and dramas. Through this most children lost their initial fears of presenting in front of an audience. The appointed officers of the society were also instructed as to how to behave and address the members. In later meetings their knowledge level on good hygiene practices was tested and all of them except for a few smaller children demonstrated that they are well aware of hygiene practices but they admitted that they rarely follow them.

It was observed that children are interested in doing activities that are enjoyable such as games rather than listening to a speech on good hygiene practices. The project team expects to make use of them in creating awareness and communicating good hygiene practices in the Wilgoda community in the future.

Lessons learned

Being actively involved and spending several months working to strengthen the capacity of the Wilgoda community to build and manage their sanitation facilities, the WASPA team faced and overcame many issues along with the CBOs and other community members. These provided several generic lessons relating to community planning, mobilization and sanitation interventions that will be of importance to other development practitioners wishing to undertake similar work.

Assuming their needs does not work always

It should never be assumed that the community wants what you think they need or that all of them have the same needs - a community is almost always heterogeneous in various ways. Therefore any activity should be conducted with their consultation as participatory measures will reveal their actual needs along with an entrance to aspects that practitioners or implementers never saw or thought of before hand.

Setting up networks

When working with one community it cannot be assumed that all the members of that community can be reached through one plan or that they have the same needs. Hence the sub-groups within the community need to be identified and approached using different methods for holistic development.

For example, in Wilgoda it was identified that the CBO committee members were all males except for the Secretary and most women did not participate in CBO meetings due to household work. Hence small women's groups were established to communicate and influence them. Similar to this the Children's Environmental Society was established to communicate with the children.

Inclusion versus exclusion

Inclusion is the best way to put an end to disruptive behaviour and mistrust. When only a few selected individuals get involved in community development activities the others that surround them feel that they belong to the periphery and may feel that their needs are not being met or that those people involved in the development have personal interests rather than the interests of the wider community. Hence due to suspicion and jealously, or merely due to misunderstandings those people who feel excluded will create problems that will hinder the development activities of any intervention.

Identifying groups that may feel excluded and that may disrupt the work and trying to encourage them to be supportive is essential. This can be done by giving open invitations to meetings and discussing concerns and plans. In this way barriers can be overcome and a feeling of ownership can be achieved, as they too are a part of the activities.

Transparency

Linked to this, the implementers need to be extremely transparent and train community groups such as the CBOs to be the same. This is the only way that they can defend themselves if they are accused of wrong-doing and also help to gain the trust of the rest of the community members. Transparency is to necessary in all aspects of the planning and implementation but is especially important in relation to finances, budgeting and record keeping. If everything is done openly then there will be no opportunity for the misuse of funds or for false accusations.

Development of leadership and capacity building

All externally funded projects have a finite time span, usually of fewer than three years, which means that it is important that by the end of the project the community take over. In order to do so the community needs to be trained step by step to take over the responsibilities which were previously handled by the project team. This requires that leadership training and various capacity building components, such as financial accounting, public speaking, facilitating and negotiating, are integral to the project methodology. In this way it is far more likely that the activities implemented by the project and the CBO itself will be sustainable.

Communication

Communication is one of the keys to successful project implementation. The dialogue between the community and the practitioners needs to have clarity without misunderstandings that will hinder project activities. Similarly communication between the small group of implementers within the community and the wider community is also essential. Building of good public relations has always proved beneficial in winning the trust of the community, an essential aspect of receiving the community cooperation.

Continued learning

The project team has learned many things from the process but it is also critical that the community themselves learn lessons and continue to analyze what they do in order to achieve further benefits and to identify solutions to problems that are likely to arise in the future.

Conclusions

This study has provided yet more empirical evidence that development interventions particularly in the areas of hygiene and sanitation gain greater acceptance and have an increased chance of sustainability if community members are involved in identifying problems and determining solutions. This process must involve all community members through good representation and transparency.

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Hygiene promotion in emergencies: A lesson for long-term health awareness

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Abstract

Over 200,000 people were displaced by the conflict in Batticaloa and Trincomalee districts and were sheltered for varying lengths of time in camps for Internally Displaced People (IDPs). To ensure sanitary surroundings in the camps was a considerable challenge in a context of insecurity and often-cramped housing conditions, sometimes on low-lying land prone to flooding. However the camp environment was also conducive to intensive education, raising awareness of health issues and establishing links with government services. After the immediate needs of the IDPs were met (water, toilets, clothes, etc.) beneficiaries increasingly took on more responsibility to manage their environment, such as the improvement of drainage channels, and the disposal of solid waste. Educational techniques and materials were used including child-to-child approaches, drama and storytelling to create awareness of health risks and improve hygiene skills in collaboration with partners and health authorities. Participatory monitoring processes were set up in collaboration with local authorities, which then took over the management and eventually the decommissioning of the camps. Good community participation, clear and systematic planning of health promotion activities, regular monitoring, timely documentation, and collaboration with government departments were effective in raising health awareness. After their enforced stay in an IDP camp many beneficiaries now have a much greater understanding of how to protect their health. However more long term monitoring is needed to find out how much the knowledge and experience gained is being used after the IDPs have been resettled.

Introduction

From early 2007 to 2008 the escalation of conflict between Libaration Tigers of Tamil Elam (LTTE) and Sri Lankan Army (SLA) resulted in large displacements of IDPs in Trincomalee and Batticaloa districts, Eastern Sri Lanka as government forces cleared “uncleared areas” of LTTE control. In April 2007 the number of IDPs peaked at around 168,000 IDPs and then decreased to around 43,000 in July 2007 as the resettlement process got underway in Batticaloa. Some of the remaining IDPs have still not yet been resettled as their homes are in “high security” zones close to the present conflict areas. This is affecting many people from villages in Mutur (Trincomalee district) who are likely to remain in IDP camps for the foreseeable future.

Over 100 camps were set up to accommodate most IDPs and the remainder took refuge with friends and relatives in towns and villages unaffected by the conflict. The IDPs arrived distressed and disorientated often having seen homes and belongings destroyed, and livelihoods ruined. Most of the IDPs were provided shelter with minimum facilities. In the short term their basic needs were met by NGOs in cooperation with government agencies, many of which were already established in the area and in the process of completing work following the Tsunami.

Table 1: Numbers of displaced people in Batticaloa and Trincomalee districts and those given support with public health services by Oxfam

DATE (Start of month)	Batticaloa		Trincomalee		Total	
	Oxfam	All IDPs	Oxfam	All IDPs	Oxfam	All IDPs
July 2006	5,300	10,000	14,000	15,000	19,300	25,000
Sep 2006	32,700	60,000	20,000	60,000	52,700	120,000
Jan 2007	14,000	75,000	8,000	10,000	22,000	85,000
Apr 2007	19,300	160,000	6,000	8,000	25,300	168,000
Jul 2007	11,000	45,000	6,000	8,000	17,000	53,000
Sep 2007	4,000	40,000	6,000	8,000	10,000	48,000
Jan 2008	-	26,000	-	7,500	-	33,500

There were considerable security concerns for much of this period in the area with regular exchanges of shellfire between warring parties, abductions, and extortion by armed groups. Protection for IDPs was difficult, as armed groups would enter the camps, which greatly increased anxiety and delayed integration into the temporary environment. In addition there were various other challenges relating to the environmental conditions, cultural issues, educational level of the IDPs, and the approaches of different agencies.

The IDPs come from areas where political control has been disputed for many years and been troubled for nearly three decades. For that reason many from the rural areas have not had the benefit of strong outreach services, particularly in primary health care. Initially they were therefore ill equipped to manage the cramped and unfamiliar conditions of IDP camps, as they lacked basic knowledge and skills in dealing with environmental health problems. However through a process of training and implementation, under the guidance of a dedicated team of Public Health Promotion staff, the situation improved dramatically.

Hygiene promotion

Hygiene promotion is the planned, systematic attempt to enable people to take action to prevent or mitigate water and sanitation related diseases and provides a practical way to facilitate community participation and accountability in emergencies. It also ensures that optimal use is made of the water, sanitation and hygiene enabling facilities that are provided. Previous experience has shown that facilities are frequently not used in an effective and sustainable manner unless hygiene promotion is carried out. Access to hardware combined with an enabling environment AND Hygiene Promotion make for hygiene improvement.

Figure1 shows that to obtain hygiene improvement hygiene promotion (community mobilisation, training, communication) must be linked to access to hardware (water systems, toilets, drainage, rubbish disposal), and an enabling environment (human rights framework, leadership, donors, health service delivery etc) for it to be effective. The graph in Figure 2 highlights the importance of behaviour change on achieving a reduction in diarrhoea when compared with water supply and sanitation interventions. Hygiene Promotion activities are managed by Public Health Promoters (PHP) who are the key counterparts to Public Health Engineers (PHE), Water Quality specialists on the technical side.

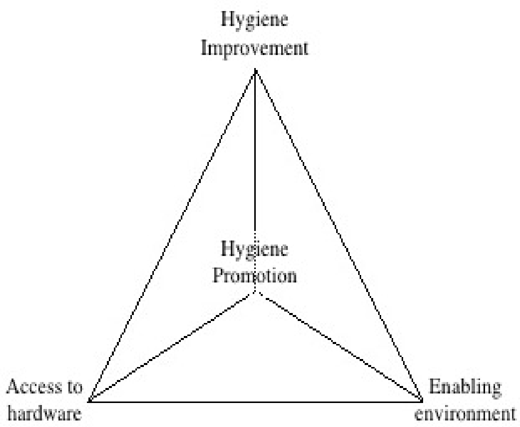
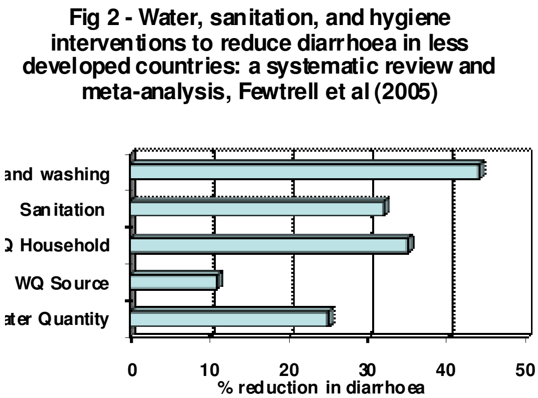


Figure 1 – Links to Hygiene and health improvement



Oxfam in emergencies

Oxfam's goal is to provide displaced people with the basic services that they need to live in good health and with dignity with a special focus on women and children. Furthermore an engagement is made to allow the IDPs to regain control of their lives so that they return to their home areas with new skills and be better placed to rebuild their livelihoods.

Oxfam's main expertise is in public health and it took on responsibilities to provide water and sanitation facilities (water treatment plants and distribution systems, wells, toilets, hand washing points, drainage channels, and solid waste management systems) as well as public health promotion in several camps. Table 1 shows the total number of IDPs and those that Oxfam assisted. In total Oxfam provided support for 5000 families in Trincomalee district and 25000 families in Batticaloa over a period of 18 months and handed over responsibility for services for the remaining IDPs to local authorities in December 2007.

Camp facilities

The IDPs were moving from rural homes to camps in more urban areas. One of the first challenges was to find suitable land for the camps where they could be sheltered. The first step is to consider general environmental conditions (drainage, access, water etc) but this was not always easy as many private landowners did not allow use of their land, and access and security issues restricted the use of much public land. SPHERE standards were used to guide the planning process (population density, water, sanitation facilities etc).

Decisions are made on site without always considering the drawbacks from a public health perspective and Oxfam is sometimes asked to provide sanitation, water, hygiene promotion at sites where shelter is already being constructed, but which are unsuitable. Some of the camps were built on paddy fields, for example, and therefore prone to flooding in the monsoon period. Others were removed from reliable sources of water. Some are housing more IDPs than they should under SPHERE standards thus increasing risks to health and well-being.

Kilivetti camp was considered the only suitable site near Mutur in Trincomalee district but security, and other practical problems relating to land ownership meant that the population density was higher than should have been the case thereby increasing the risk to health. Ideally agencies like Oxfam should be more involved in the choice of sites to avoid such problems.

Immediate needs

A rapid needs assessment was conducted with the IDPs to establish immediate priorities. Focus group discussions were held with key informants representing women, religious leaders, community leaders, children, and those with special needs. These discussions were followed up with a baseline survey to document conditions and provide a level to measure improvements. Regular monitoring was organised to ensure community acceptance of Oxfam's response.

Essential Non Food Related Items (NFRIs) such as toiletries, sanitary towels, soap, toothpaste etc were distributed regularly (every two months) and advice was given to ensure that their uses were fully understood. Tools such as buckets, wheelbarrows, brushes etc for maintenance purposes were also provided though more regularly than was planned initially as IDPs often took them when they were resettled. However after discussion with the camp management committees the situation improved.

Participatory design

Disease outbreak is the common consequence following displacements of people to crowded areas and an organized effort is essential to reduce high-risk behaviours. Hygiene knowledge of IDPs was limited and there were many examples of poor sanitary practice.

The geographical condition of the sites dictated the way facilities were constructed and the engineering team were fully deployed to overcome technical problems. The Public Health Promoters ensured that the designs developed by the engineers matched with their understanding of the needs expressed by the IDPs and their cultural beliefs (siting and design of toilets for example). After completion responsibility for the facilities was handed over to the beneficiaries, monitoring committees were set up and training provided. Many of the IDPs had not used the types of public health facilities that were provided before their arrival so their existing knowledge needed to be developed and sustainable behaviour changes introduced.

<u>IDPs ditch design of drainage</u>

Santhiralinkam Kirubadevi, a 35 year old mother of four, and leader of Paddithidal IDP camp raised her voice at the Oxfam/Sarvodaya monthly camp meeting. It was all about the wastewater disposal and the coming rainy season. Like Kirubadevi, all the IDPs from this camp felt that they needed a good system to keep the camp clean and safe from flooding.

Padithidal IDP site is located in a school ground, and was selected for temporary settlement, so issues like flooding were not considered properly during the initial assessment. Oxfam arranged for the shelter agencies to raise the land area to reduce the risk but it was not enough. Since the resettlement process was slow people realized that this camp would be long-term and they decided to do something about it.

Oxfam brought this matter to the camp management and a feasibility study was conducted. After much discussion a final design was brought to the site and community consultation started. The IDPs agreed with the Oxfam plan for a permanent drainage system (1400 m) but they did not agree with the design. The IDPs were well aware of the public health consequences following the improper construction of services but said they would be responsible for keep the system clean and problem free. The work was carried out under cash for work and was completed successfully with the support of IDPs. After 2 months Kirubadevi again raises her voice, to remind those responsible to clean the channel in the early morning as agreed in the schedule.

Community mobilisation

Camp management committees were formed to administer the camp and gain maximum participation from the beneficiaries thus creating a sense of ownership and responsibility. Members were respected persons chosen by the community. They managed a cadre of volunteer community mobilisers and organised groups to monitor water points, maintain toilets, and manage solid waste. Oxfam facilitated this process and also developed the linkages with other stakeholders.

The development of a cadre of volunteer community mobilisers is the key to public health promotion in IDP camps. They are selected by the community through the camp management committee and trained by Oxfam/partner. Each volunteer takes care of 20-30 families. These volunteers were the key health staff in the IDP camps responsible for home visits; distribution of materials; advising the camp management about health issues; with technical workers to do repair work or respond to an emergency such as water supply or drainage difficulties. In addition they provided links with the curative services of the Department of Health, and helped to prevent disease outbreaks. Most were enthusiastic community representatives but there were concerns among some of being more exposed to harassment by armed groups.

<u>Mr. Mankoran's transition</u>

Engaging people to maintain health in a camp setting is a big challenge. For various reasons, poor motivation, difficult living conditions, frustration, people do not participate, and sometimes actively discourage others from being active. So it can be difficult to recruit volunteers but with persistence and effort it is possible to win over even the most resistant.

Mr. Manokaran was displaced from Trincomalee district to an IDP camp in Batticaloa by the conflict. Soon after the camp was established 25 mobilisers were identified to support health activities in the camp. Mr. Manokaran was very unsupportive and undermined the work of the other mobilisers with malicious gossip, and became a headache for all the workers.

However after PHPs and volunteers had visited Mr Manokoran's family several times following sickness to advise on healthy practices his attitude changed. He began to understand the importance of the mobiliser's work. One day he came to the health promoters in the camp and asked to become a volunteer "to change people who are living like me and make them understand the importance of healthy life".

This was a big success for the programme as Mr. Manokaran then became one of the most active of the volunteer community mobilisers, taking part in drama and many other activities, and an outspoken advocate.

Unfortunately there was a shortage of male volunteers and many more female then male. In future the recruitment of male volunteers should be a priority. However it was an achievement to develop the capacity of female volunteers so that they able to take a lead in promoting better hygiene practices among the community.

Hygiene promotion

The knowledge of IDPs on health issues was low so a training package was developed with the help of the Health Department. Adult learning is a challenge and there was a special emphasis on participatory training linked to the particular needs in the camp. IDPs were helped to identify their own high-risk behaviours and facilitated the drawing up of an action plan to overcome these difficulties.

Firstly though training was conducted to over 500 community volunteers on:

- Survey techniques to understand knowledge, attitudes and practices
- Hygiene promotion methods
- Community risk mapping including the identification of high risk practices and the development of monitoring tools
- Communicable diseases
- Operation and maintenance

A Hygiene Promotion Manual and hygiene tool kits composed of IEC materials was developed and published in collaboration with the MOH and UNICEF to guide the volunteers and government health promoters. The hygiene promotion methods included house visits, group discussions, meetings, drama/songs, story telling, children drawing sessions, children hygiene play activities, on the spot hygiene promotion and mobilisation, campaigns on persisting risk behaviours, child to child programme, and health campaigns.

Visual tools were used wherever possible such as printed colour cards that told a story or formed similar group, or games such as snakes and ladders with a health theme. Street theatre was used effectively in some areas and was very popular with younger people.

Children

Special attention was given to children as behavioural formation is much more effective than behavioural change. Methods used were teaching (adult), mimicking, playing, and child-to-child. The child-to-child approach was particularly effective as children easily form their behaviour changes and pass them on to their peers. The steps taken were:

- Contact with parents, teachers & community leaders
- Worked with children of similar age and included them in decisions
- Helped children to share their discoveries
- Reviewed the activities, encouraging the children to evaluate success and how they might do things differently next time

- Decided how to involve teachers / nurses in evaluating success of the project

Child to child approach recognizes the potential of children to learn and care for one another and their capacity for learning. By using various teaching methods like chalk and talk, group discussion, stories, pictures, experiments, surveys, drama, songs, poems and games were used for children to understand and apply better hygiene practices. The process was sensitive to children's needs and care was taken to ensure that:

- Messages were not passed on that they do not fully understand
- They did not do dirty or boring tasks that adults do not want (digging latrines),
- Activities were not exploitative

The child-to-child method reached children and they enjoyed it. Oxfam found a big change in children's hygiene practices and they became strong in insisting that better hygiene practices are applied in the household. Unfortunately Oxfam only started 4 months before the end of the programme and had we started earlier would have seen a greater impact on children's behaviour.

Maintenance

Oxfam spent a great deal of time with IDPs to create ownership and camp committees played a crucial role in this regard. Initially people were employed to maintain the facilities but when the IDPs recognised them as their own they took over the responsibility. Wherever possible the facilities have to been allocated to groups of family units who then decide what way it is to be maintained. Oxfam assists this process through training. As much as possible is left to the camp management committee and family groups as Oxfam has found that maintenance is more effective if there is a simple system decided upon by the users themselves.

Mr. Sivalingam's storytelling

Children in the IDP camps often feel left out and more vulnerable in a strange situation where there is no school. In this situation, we felt that there is need to support children in terms of motivating them towards improved personal hygiene and basic hygiene practices.

Mr. Sivalingam is a very famous storyteller in Sri Lanka and India and he is from Batticaloa. He has many stories for children and can mimic very well the different sounds of animals. Oxfam hired his services regularly to visit IDP camps and organise story-telling sessions. In these stories, the importance of personal hygiene and basic hygiene practice to live healthily in IDP camps figure prominently.

Cleaning campaigns

In Camp Church after identifying volunteers a one-day camp cleaning campaign was organised and 800 IDPs took part. Before flies, mosquitoes, garbage (especially plastic and food) were found in the camp; drainage and maintenance of water and sanitation facilities were major issues. After the campaign there was a remarkable change in the cleanliness with volunteers playing a key role in maintaining a healthy environment. Every week “shramadana” (free labour contribution) is given for the cleaning of the camp as well as for the maintenance of basic facilities.

Bathing and bananas

The bathing areas in Savukady IDP camp contained tube wells with an apron, screen and drainage facility. Banana trees were planted to use the drainage water and with proper drainage maintenance has helped to keep the environment clean and prevent the mosquito breeding. Drainage waters from the bathing area support the plant growth and have contributed to livelihood activity. Plants also improve the soil permeability and infiltration capacity.

Monitoring

A participatory monitoring system was set up with the MOH to monitor disease, behaviour and practices, toilets and water points, and other needs and issues. Regular home visits were made to monitor household level water quality, the genera home environment, food hygiene, and to hold discussions with women about family hygiene issues. Home visits enabled PHPs to establish a rapport with IDPs, and allowed IDPs to understand and solve problems for themselves.

There was a special focus on key risks identified by the community:

- Safe disposal of children excreta
- Maintenance of wastewater and drainage.
- Hand washing after defecation.
- Unsafe handling of drinking water and risky water storage.

The results of the monitoring process fed back into the hygiene sessions ensured improvement in the knowledge and practices of the IDPs, and no outbreaks of water and sanitation related diseases were reported. Little sign of open defecation and clean toilets also indicated that latrines were used and properly maintained.

Coordination

The responsibility for managing the IDPs was taken on by government through the local authorities, but initially they lacked the capacity and resources to cope with an influx of this kind. UN agencies and NGOs therefore took on lead roles. The water, sanitation and hygiene promotion sector was coordinated by UNICEF and some of the International NGOs involved were ICRC, IOM, Arche Nova, ACTED, ACF, WorldVision, Solidarite, IFRC, Merlin and Oxfam, and local NGOs such as ESCO, CRDO, NERTRA, EUDA and Sarvodaya. Regular coordination meetings were held that included representatives from the Ministries of Health, Local Government Departments, and the National Water Supply & Drainage Board. The links between NGOs and other organisations are shown in Figure 2.

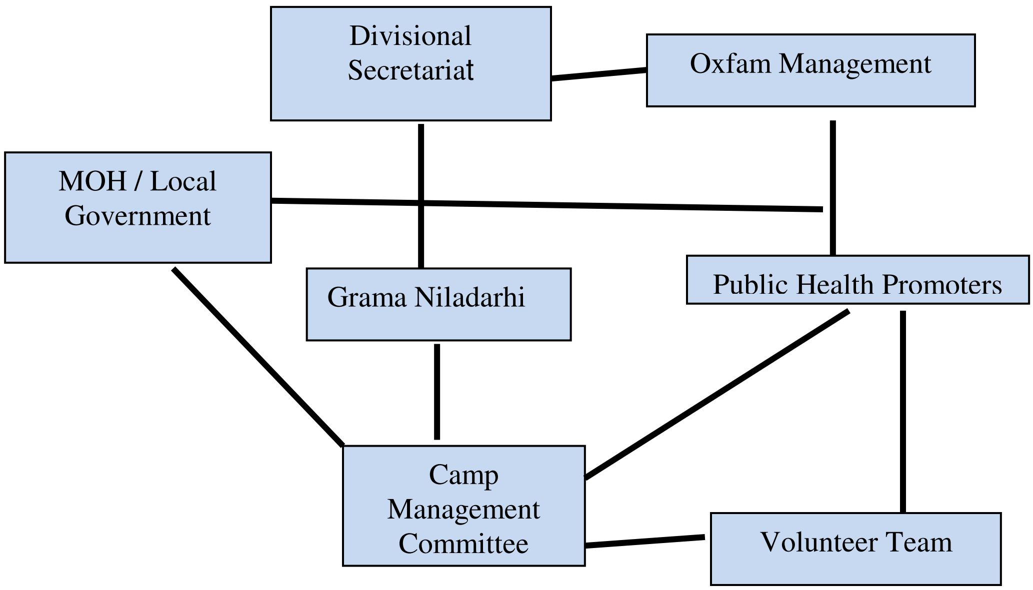


Figure 2: Responsibilities for IDPs.

Coordination was vital for the overall management of the IDP response as miscommunication was common. Different agencies understood tasks in different ways and the only way to avoid unnecessary delays or duplication was to hold regular meetings, and to communicate often and informally. This was especially true in an environment of conflict and heightened tension, as security demands greatly hindered the delivery of services. Roads were often closed, material transportation to sites needed military clearance and the establishment of a 50m open zone on either side of the roads also disrupted the planning of facilities in camps.

The entire response was designed according to the accepted common (SPHERE) standards. It was agreed that the authorities would take over direct responsibilities for the IDPs once they had the capacity. In the meantime joint training programmes, resource materials development and project sharing have taken place to deliver services to the affected communities.

Conclusion

Overall the programme achieved a good big improvement in hygiene awareness and knowledge amongst the IDPs. SPHERE standards were met in the provision of clean water, safe excreta disposal facilities, bathing facilities and waste disposal. Special focus was given to the needs of women and children. No outbreaks of communicable diseases were reported and although we learnt that there were some isolated cases of diarrhoea, chicken pox and eye infection, they were understood to be due to cramped living conditions rather than a failure of public health (PH) services.

Latrines were used and kept in good condition indicated by minimal signs of open defecation, and there were improved practices in hand washing and people drinking chlorinated water are the significant change noted in the IDPs' habits. However there are still some evidence of habits amongst IDPs requiring further attention and this are mainly around safe disposal of young children's faeces and safe handling and storage of drinking water.

For much of the time Oxfam was working through local partners and it was also an opportunity to develop their capacity to work in this type of emergency. They will now be ready to respond in any future situation. Towards the end of our responsibility in the IDP camps competing demands with the resettlement meant that partners were unable to give the support that they had previously but there was no noticeable change in conditions in the camps.

Most of the IDPs are now resettled and are focusing on rebuilding their lives. During their stay in the camps they have had an intensive experience and in the process acquired a greater understanding of health issues, which should help them in the future. And not only have the IDPs acquired new skills and understanding but also they are more aware of the services that are provided by government agencies. Oxfam continues to support the resettlement process and ensure that returnees have basic facilities (clean wells, repaired toilets) to build the phase of their lives.

An evaluation is planned to assess the impact of training received by the IDPs and applied in the camps, and whether behaviour changes and outlook have continued after resettlement. It would be a great achievement if IDPs could take home real gains from their enforced stay in camps in understanding and knowledge that they could apply for the benefit of their families in the future.

Water and sanitation in (post) conflict areas of North-East Sri Lanka: Technical solutions based on quick impact and do no-harm

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Abstract

Water and sanitation are vital for human health, generates economic benefits, helps the environment and contributes to dignity and social development. Irrefutably, water, sanitation and health are interrelated. Thus access to adequate sanitation and quality water is essential for better health and overall living conditions.

This is applicable in general, but more crucial in (post) conflict situations. People in such circumstances do already have a difficult time and are often more vulnerable. As in the case of recovery phase, specific water and sanitation needs have to be fulfilled during emergencies as well (e.g. conflict or disaster like Tsunami).

In each phase a specific approach is needed to provide the people with suitable water and sanitation (watsan) solutions. The interventions should be based on quick impact and do no-harm.

This paper suggests basic solutions that can be implemented fast enough as timely interventions in emergencies and that can assist people quickly for rehabilitation, but have no significant negative (long term) impact. Also specific options are suggested for development phase. Several technical solutions together with issues like sustainability, ownership, community mobilization (participation), etc. are also discussed.

Need for WatSan in (post) conflict situations

As mentioned, water and sanitation are especially important in post conflict situations. In emergencies water and sanitation is often essential for people to survive and to prevent outbreak of diseases that could cause more casualties.

Post-conflict situation like during the ceasefire agreement (CFA) or after a disaster like the Tsunami, when people are settled again to live in a particular place, they need the rehabilitation of water and sanitation facilities to be able to recover and to restart their lives. The rehabilitation becomes gradually replaced by development when additional facilities are provided or facilities are improved. When people can

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take enough water close by their home, it does not only save a lot of time and energy to bring the water to their home but also ensures enough water for cleaning, bathing and often also for purposes like home gardening or even some agriculture. Better sanitation not only ensures safe health, but also improves self esteem and psycho social well being. Problems for women like harassment or abuse can be prevented if toilet facility is available in their own compound instead of going to common places like the jungle or sea. Also, it prevents them from drinking (too) little water to reduce the frequency of urinating especially at night.

The relief, rehabilitation and development solutions should not only be technically feasible, but also based on quick impact and do no-harm. In emergencies it is probably more important to provide half of the required (sphere) amount within say 2 or 3 days, than providing the full amount after one or two weeks. For rehabilitation it is important that all the people get the basic facilities as soon as possible to assist them in starting up their lives and to increase their self esteem to enable them to focus on other issues than their daily struggle to survive. Special attention is needed for the extremely vulnerable households, like female headed households, families with many small children, families with disabled members, etc. Without basic facilities being restored, it is difficult for them to think about peace and future developments.

Figure 1: Need for basic facilities (shelter and watsan) in (post) conflict areas

The interventions should also be based on do no-harm. In emergency, this means that providing bad quality water could create more risk than providing no water at all. In rehabilitation, there is a risk of providing the wrong solutions like a toilet that becomes flooded during the rain or assisting a family that doesn’t fit into the criteria. However, there is also a perhaps more serious risk that people are not getting enough assistance. The later could happen during emergencies where quick action is needed, if the facilities being provided is not wanted for certain reasons by (local) authorities or if the expectations are too high. If technical standards are raised to a very high level, people are actually prevented from getting assistance as the donors are not able / willing to provide such facilities and / or the progress in providing such assistance is low.

For development the watsan facilities can be improved through introduction of new technologies, for example eco-san toilets or the amount of facilities can be increased while making more time available for research and implementation.

Table 1: Different phases with suitable watsan interventions

Phase	**Emergency Relief**	**Rehabilitation**	**Development**
Situation:	Emergency, displacement	Resettlement / transitional phase	Stability / permanent phase
	War, conflict (or disaster like Tsunami)	CFA / No war – no peace	Peace
Watsan intervention:	Quick (days) temporary facilities	Quick (months-years) basic (semi-permanent) facilities	Gradually (years) improvement / increase of facilities / new technologies
Beneficiary participation/ contribution	In general not possible	Participation as far as possible (attention for extremely vulnerable families)	Participation and own contribution to improve ownership

Situation in Sri Lanka

General situation in Sri Lanka

Normally people in Sri Lanka use water sealed toilets. In the cities toilets are nowadays mostly attached to the house, but in the rural areas toilets are mostly built separately. In urban areas these toilets are connected to a sewerage system, septic tank or soakage pit. In rural areas the toilets are in general connected to a soakage pit and rarely to a septic tank. The poor households who cannot effort to build a toilet use often a dry pit in their compound.

Situation in (post) conflict areas (North-East)

In the rural (post) conflict areas, people expect to have a pour flush toilet with soakage pit. In general people have relatively large compounds (> ¼ acre) and therefore a minimum required distance (100 feet) between toilet and wells can be kept. Most families do not even have a private well. Due to the conflict and displacements, either the toilets were damaged or the families have never been able to buillt a toilet due to either poor income or unavailability of cement. In certain districts only a small percentage of the population has a real toilet, the others have to use a pit, corner of their compound or go to the sea or jungle.

If for example Kilinochchi district is considered, in 2005 almost 36.000 families were registered of whom most (64%) have returned after being displaced due to the conflict. Some families have built toilets by themselves or with the assistance of programmes of the GoSL and INGOs during the CFA, but most people (probably

75%) still did not have a toilet even when the CFA came to an end. Similar applies to other (parts of) North Eastern districts.

Situation in Tsunami affected areas

In the Tsunami affected areas in the North-East, many fishermen families were restarting their lives during the CFA. The coastal villages were somewhat more densely populated than the inland villages as the fishermen like to live close to the sea and therefore prefer to occupy the coastal belt directly bordering the sea.

If these families had water and sanitation facilities, these normally existed of a shallow well and a pour flush toilet with soakage pit. However, many families were still using the sea and jungle around as toilet and were depending on certain common wells for drinking water. Only in some town areas there was pipe born water and in the town most compounds had a kind of toilet.

Due to the Tsunami devastation, new houses had to be built including water and sanitation facilities. In some cases this was done in the original plots, but more often a land was newly planned and divided in to plots. The new lands can be seen as similar to urban areas where the plot seize is relatively small (<20 perches) and a complete new setup had to be made. On top of this, many sites exists in relatively low land with high groundwater tables. Therefore, rehabilitation of water and sanitation facilities like the one that the people had before was not always suitable and new plans had to be made (see also Navaratne, 2006). As long as the permanent structures were not ready, transitional water and sanitation solutions were needed.

Watsan solutions

Watsan – relief

For emergency relief it is important to be able to quickly provide watsan facilities. The Sphere standard mentions that initially one toilet per 50 persons should be the target, which then can be changed to one toilet per 20 persons. However no set timeframe is mentioned. It would be good if an indication of a timeframe was given, like within 3-5 days one toilet per 50 persons and within another 3-5 days 1 toilet per 20 persons. Such a timeframe will prevent agencies from competing after installing necessary toilets and will show that agencies not only have to focus on quality but also on progress. Sometimes donors come after a few weeks and could see only the final result and not the progress. However not only the final product but also the process of implementation should be valued.

Very basic solutions, like excavating a ditch are described in several handbooks, however it is questionable whether people will use such facilities or will go to other places. Some agencies have stock of fibre glass slabs that can be used as squatting pan. However with locally available materials, temporary toilets can be set up very fast. One example is shown in Figure 2 where normal squatting pans is used. An empty half barrels is used as the foundation for a squatting pan and an empty barrel is used as the soakage pit. In situations with low infiltration capacity (low permeability or high groundwater table), a second barrel can be connected to the first barrel so that if the water overflows, the water can infiltrate through two barrels. The rooms around the toilets are made out of plastic sheet fixed to jungle sticks. There are many advantages of using these local materials: a water sealed toilet is provided, materials are commonly available at relatively low prices (compared to importing special products and keeping in stocks), labourers are familiar to install these materials and the toilets can be constructed within a short period.

While it is not always known how long people will stay at a certain place in emergencies, the volume of the pit does not need to be very high. If the capacity is not big enough, new toilets can be made or additional pits can be constructed. As long as the toilets are not set up too close to a well, there are no real negative impacts of these temporary toilets. If cleaning materials are provided, people can keep the toilets clean or a hygiene promotion committee needs to be organised.

Figure 2: Constructing temporary toilets with local materials

Watsan – rehabilitation

When the situation improves for the ordinary people, like during the CFA, rehabilitation can be started. When people return to their original places, often water and sanitation facilities are also missing. In general a private (cement block lined) well is not affordable, so for water they depend on common wells. If they build a toilet this is mostly a pour flush toilet with a simple pit. While many households, especially the extremely vulnerable households, are not in a position to construct such toilets, some programmes of the GoSL and NGOs assist them with this type of toilets.

Figure 3: Pour flush toilets with soakage pit – complete with room

Although a septic tank might technically at first seem to be a better solution (no direct contact with groundwater), a toilet with simple soakage pit is for many circumstances as part of a rehabilitation programme still the most suitable option because:

- in rural areas with relatively large plots, large distance between toilets and wells can be maintained and often households do not even have private wells;
- in areas with high groundwater table, the whole construction can be elevated higher above ground level;
- often the groundwater table is present only for a short time per year (during the raining season) at its highest level, so most of the time groundwater pollution will not take place;
- if wells are in the neighbourhood of a toilet, these are normally designed for the dry period, so groundwater that becomes slightly polluted by pits (at about 6' below surface) during the raining season will not enter the wells as the water enters from the bottom in a lined well (at 20 – 30' depth)
- proved solution, no negative impacts except for in some highly populated town areas (e.g. Jaffna: groundwater pollution);
- construction of the pit is a simple technique and can be done by the beneficiaries (participation / ownership), for a septic tank of reinforced concrete skilled mason have to execute the work;
- because of the simple technique, no risk of failure (if a septic tank is not water proof, it actually doesn't function properly);
- no or very low maintenance (if septic tanks are not cleaned after some years, they will not function properly);
- no or limited budgets for expensive options like septic tanks for rehabilitation where quick impact is required (many toilets in a short period can be built).

In several manuals / guidelines, it is recommended that the bottom of the pit should be 2.5 m or 3 m above the static groundwater level. Based on the points mentioned above, it seems reasonable to accept toilets with soakage pits also if the groundwater level reaches a higher level (up to about 1.5 m) for a short period during the raining season if distances to wells are large and in soils with low permeability. It is recommended not to decide only on the maximum height of the groundwater table, but at least to take the population density / plot seize into account.

People normally prefer a completed toilet with cement block wall room. However for health and hygiene reasons, a proper base with water sealed squatting pan connected to a (lined) pit with some cheap kind of room around the base would be enough (i.g. cadjan or tin sheet). There are several reasons that agencies assist with a complete toilet: some (local) authorities allow only 'full assistance', some donors like to see complete products, only a base and pit doesn't look professional (no nice pictures), etc.

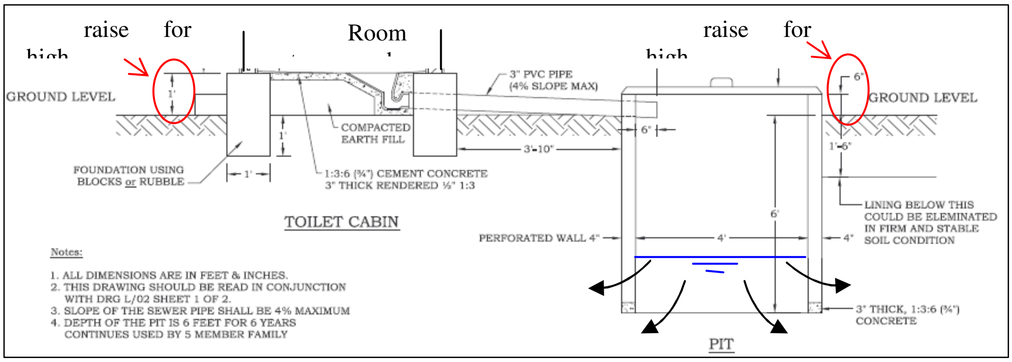

Figure 4: Pour flush toilets with soakage pit – room to be constructed by beneficiary

However, if assisted with only the base and pit it is possible to provide assistance to many more households (2-4 times) with the same budget. Beneficiaries can be mobilised to do some part of this work themselves asit doesn't require much skilled work. For example, they get cements and sand to make blocks if a pit is excavated and they get a second batch of cement and the other materials to finish the work.. The beneficiaries can finish the room whenever they want and according to their own choice. This participation and the need to finish the room themselves will also improve the ownership of the toilet. If it turns out that specific vulnerable households cannot really finish a toilet, the room can be provide as part of the development programme.

The risk of groundwater pollution by providing simple soakage pits, is in most situations pause much smaller risk than giving no assistance because of lack of funding for expensive options (like septic tanks) or results too low progress.

For the transitional phase after the Tsunami, semi permanent watsan solutions have been provided. For example in Vaddamarachchi East and Mullaitivu per 10 families 5 toilets connected to one pit were provided. These toilets had a normal squatting pan fixed in a base of cement and were finished with a room of tin sheet. At certain transitional camps, piped water was provided from an overhead tank for drinking as well as for bathing places. ZOA Refugee Care decided to provide only water for drinking, while for bathing one well per 20 families was constructed. This was proved to be a much more sustainable solution. Less water had to be pumped from the drinking water wells (preventing water shortage and salt water intrusion problems) and the bathing water could be drawn from a larger number of wells by people themselves as they are used it. Also much less operation and maintenance was needed.

Figure 5: Semi-permanent watsan facilities in Tsunami transitional camp

Watsan – development

For water and sanitation in development, the facilities can be improved or more facilities (like wells) can be provided. If needed, simple soakage pits can be replaced by septic tanks or new technologies like ecosan (composting toilets) can be tested. Also for septic tanks, still the effluent needs to be diverted somewhere. An easy solution is a soakage pit or trench, but an evaporation bed or sewerage system also can be used.

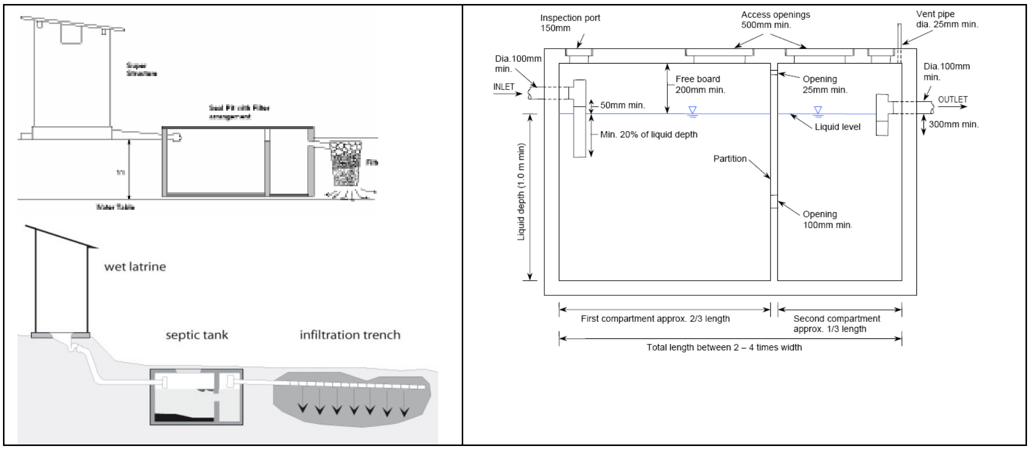

Figure 6: Pour flush toilets with septic tank and soakage pit or infiltration trench.

In situations with high groundwater table, the problems for a normal soakage pit toilet or septic tank are a bit the same. The water level in the soakage pit needs to be somewhat higher than the groundwater level to be able to infiltrate and therefore the toilet and pit have to be raised (see Figure 4). The effluent from the septic tank also needs to infiltrate and therefore a toilet with septic tank also needs to be raised completely (base, tank and soakage pit). For (urban) situations with high groundwater levels, it is in fact the best solution to lower the groundwater level for the whole area in combination with raising the ground level and / or a sewerage system. Further, improving the operating of the septic tank is possible by introducing secondary treatments before the water drains into the ground or surface water, like a biofilter, lined / unlined wetland or seepage bed.

In the development phase, more attention can be paid to community mobilisation, to be able to introduce common systems like water pipeline and / or sewerage. The time frame can be longer while the people should already have the basic facilities, so that funds can be arranged and proper planning / designing can be done.

In sandy areas with shallow groundwater, private wells can be relatively easily provided by using hume pipes. This can also be considered for rehabilitation as shared wells (i.e. a well for 4 families). Although not popular in Sri Lanka, shallow tube wells with hand pumps could be a good alternative to open wells. Some misunderstand in the use of hand pumps exists as they think that this has a negative impact on the groundwater, however if water is taken from the same aquifer as by the open wells, the impact is same or even less (less wastage, less chance for pollution). While families are not used to hand pumps, awareness and explanation will be needed. Also maintenance issues have to be taken into account.

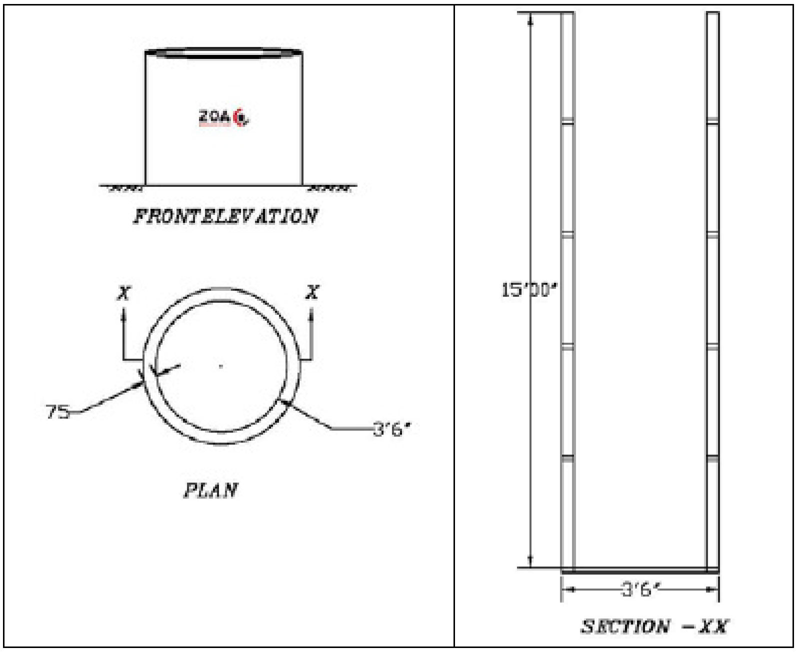

Figure 7: Well made of hume pipe

Conclusion and recommendations

For proper water and sanitation solutions it is important to consider the particular situation for which these solutions are provided, like for relief, rehabilitation or development. In general more attention is paid to technical standards, but less to progress and impact. Even the international Sphere standards (emergency) do not focus on the progress, although it would be good if an indication of a timeframe was given like within 3-5 days one toilet per 50 persons and within another 3-5 days 1 toilet per 20 persons. In this paper it is advocated that solutions also should be based on quick impact and do no-harm.

Similarly for rehabilitation it is impossible to provide the best water and sanitation systems within a short time or to expect people in the mean time to live without water and sanitation facilities at all. It is suggested to provide all families with the basic facilities as soon as possible so that do no-harm approach can be further promoted in the future. Like after the Tsunami, it was widely accepted that people first got a transitional shelter and after that a permanent house.

In general, for choosing the type of toilets, the groundwater level is used as an indicator. However, it is recommended to consider other aspects such as whether it is for rural or urban areas, whether the highest ground water level occurs only for a short time and the difference between high and low groundwater level is large (sometimes more than 20 to 30 feet) and whether the distances to wells are large. Based on such indicators it would be adequate to provide normal soakage pit toilets in rural areas (land plots ≥ ¼ acre) and septic tank toilets or other options only in urban, densely populated areas.

To be able to have high progress for the rehabilitation and to improve the participation and ownership of the people, it is recommended to provide only a proper base with squatting pan and pit and let the families finish the toilet rooms. In this way more families can be assisted with a technically good solution within a short period and finished the rehabilitation phase early. In the development phase, specific families can be assisted further with improved systems; e.g. septic tanks or sewerage systems.

Special attention is required for areas with high ground water levels (also this occurs only for a short period) to ensure that the toilets can be used always. Normal soakage pit toilets can be completely raised but same is needed for septic tank toilets as well.

In (post) conflict areas like the rural areas in the north and east, many people live without basic water and sanitation. For them it is important that they can live as soon as possible with basic facilities and therefore rehabilitation is needed. In the guidelines for water and sanitation not only the technical aspects need to be included, but the solutions should also be based on quick impact and do noharm. The solutions should not cause any direct harm (e.g. drinking water pollution), but also no indirect harm like preventing people from getting assistance by raising the standards which require high budgets. For development, more time can be used to arrange funds to introduce more sophisticated systems or new technologies.

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Application of ecological sanitation technology/s to Pussella-Oya sub catchment – A concept note

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Abstract

Pussella-oya is a 3rd order stream of river Mahaweli. The major land uses of Pussella-oya catchment comprises with tea estates, agricultural lands, peri-urban, rural and estates dwelling areas, and natural forests. Catchment belongs to the WM2 agro-ecological zone having red-yellow podzolic soils as the major soil type, and receives 2500-3000 mm of rainfall. Pussellawa, Wahugepitiya and Paradeka as peri-urban areas, eight estates, and rural villages belong to nine GN divisions are located in the catchment.

Contamination of Paradeka and Newpeacock water intakes of the National Water Supply and Drainage Board (NWS&DB) and all other water sources are highly evident in the catchment, and it has resulted serious health and environmental issues. Investigation of the existing situation and drawing the issues and root causes network using qualitative analytical techniques shows that lots of environmental, socio-economic and institutional aspects are governing the poor sanitation of the communities in the catchment. According to the WHO definition, sanitation is usually refers to "the collection and disposal of excreta and community liquid waste in a hygienic way so as not to endanger the health of individuals and the community as a whole". The conventional septic systems and cesspits do not work in most of the places within the catchment due to shallow water table, inadequate soil permeability, rocky conditions and lack of water availability for flushing. Ecological sanitation refers to use of human excreta as a valuable and manageable resource, and it minimizes the contamination of water with human excreta using cost effective methods. Considering all the environmental and socio-economic aspects, the paper describes the appropriateness of ecological sanitation for the Pussella-oya sub catchment.

Introduction

Pussella-Oya is a third order stream of river Mahaweli, which starts from central hills of Sri Lanka. The catchment comprises of tea estates, agricultural lands, peri-urban, rural and estates dwelling areas, and natural forests. Catchment belongs to the WM2 agro-ecological zone having red-yellow podzolic soils as the major soil type, and receives 2500-3000 mm of rainfall. The environmental conditions act as constrains for conventional sanitation at some places, leading to contamination of groundwater bodies. Pussellawa, Wahugepitiya and Paradeka as peri-urban areas, eight estates, and rural villages belong to nine GN divisions are located in the catchment.

Though the goal -7 of the millennium development goals in Sri Lanka targets ensuring environmental sustainability is declared as “Prudence must be shown in the management of all living species and natural resources in accordance with the precepts of sustainable development” (National council for economic development, 2005) the country reports does not much focus on the prevention strategies of environmental pollution. Sanitation improvement programs are implemented throughout the country without having a national policy thus may create some failures in huge sanitation projects. High-tech, centralized solutions consume lots of energy which is costly. So that the importance of low-cost sanitation systems is need to be considered in the sanitation improvement programs.

The guide to strategic planning for municipal sanitation has developed by the GHK research and training limited in association with water and engineering development centre, draw some important steps to follow for sanitation improvement and to selection of appropriate technology. It is important to note that the choice of sanitation technology must start from an assessment of the existing situation, take different people’s objectives into account and make use of shared knowledge. Processes of sanitation choice should be designed to ensure that sanitation services are affordable, acceptable to users, and appropriate to the situation (GHK research and training centre, 2000). In terms of sanitation technology choices, it is important to look at the past experiences of its applications and reasons for success or failures in similar situations. The situation analysis of the Pussella-oya sub catchment helps to determine the applicability of different sanitation options suitable for that specific situation.

Ecological sanitation (also referred as “Eco-san”) offers a new philosophy of dealing with what is presently regarded as solid waste and wastewater. Eco-san is based on the systematic implementation of reuse and recycling of nutrients and water as a hygienically safe, closed-loop and holistic alternative to conventional sanitation solutions (Wikipedia, 2008). Ecosan systems enable the recovery of nutrients from human faeces and urine for the benefit of agriculture, thus helping to preserve soil fertility, assure food security for future generations, minimize water pollution and recover bio-energy. They ensure that water is used economically and is recycled in a safe way to the greatest possible extent for purposes such as irrigation or groundwater recharge (Wikipedia, 2008). In conventional sanitation, excreta are generally regarded as a problematic waste to be disposed. Ecological sanitation (Ecosan) is a concept that treats various types of waste generated by us as a resource which can be safely collected, treated and reused to prevent pollution of water bodies and the environment. Currently, various types of Ecosan practices such as promotion of Ecosan toilets, compost pits, bio-gas plants, reed-beds for treatment of waste water, etc., are being taken up to treat waste generated by p in a ecologically sound manner. (WES Net India, 2008)

Energy is a crisis in Sri Lanka, where the alternative energy sources are essential to reverse the situation. Increasing energy demand and market prices of energy sources in Sri Lanka have indirectly shows that there is a need to recognize alternative energy options. Bio-gas is such option which can be worked as a sanitation solution as well. Appropriateness of the bio-gas technology for study area has not yet been assessed, considering the environment and socio-economic factors into account. Bio-gas technology is an energy option which can be used to prevent faecal contamination of water resources occurred due to poor sanitation.

The objective of this concept note is to assess the present sanitation situation of the Pussella-oya sub-catchment and discuss the applicability of ecological sanitation concept.

Existing Situation in Pussella-oya Sub Catchment and Failures of Conventional Sanitation Technologies

Qualitative and quick situation assessment of the catchment was carried out using participatory research methodologies and tools. Rothschild estate is the upper most places in the catchment where the community is lacking the sanitation infrastructure. All eight estates belong to the catchment faces with sanitation and hygienic problems, but situation differs from one to another location. Even though more than 90% of the Melfort estate community has been provided with adequate sanitation infrastructures, peoples' behaviours such as washing baby stools into the open drain, and lack of hygienic practices such as using soap could be observed. Since estate people are living in line rooms as clusters with limited land space, hygiene conditions are found to be not satisfactory. Limited space, shallow water table at some location, scarcity of water, and sometimes rocky conditions has caused failures of existing sanitation infrastructures. The settlements along the stream banks potentially pollute water by locating their cesspits at the stream bank. Pussellawa is the main peri-urban area which is located in the catchment. Community in the township contributes to water pollution by directly diverting their septic tanks into the open storm water drains during the rainy days. According to the health records of Udapalatha MOH and estate medical doctors, occurrence of water related diseases are very high in estates, and Pussellawa town. Viral hepatitis disease outbreak in the year 2007 made people and authorized institutions to pay more attention for sanitation in the area. Number of hepatitis cases reported in Gampola Medical office of Health (MOH) area was 825 out of 1975 cases reported in the Kandy district. Two drinking water intakes of the NWS&DB are located in the Pussella-oya which may leads to spread the disease among downstream people. Higher number of patients from the Gampola town area also revealed that the poor sanitation facilities in the Pussella-oya catchment have caused to the health issues of people in downstream. Lots of people in the catchment use unprotected wells and springs for domestic purposes; few samples taken from drinking water sources answered positively to the qualitative test for Coliform using H2S strip method.

The map shows the e-coli range of the selected sampling points from drinking wells and springs of various places of the catchment (Figure 1). It reveals that the Blackforest colony has the highest contamination levels. Thirty samples were analyzed during the study and coliform counts of all samples were higher than the recommended level (0 CFU/100 ml) by the World Health Organization.

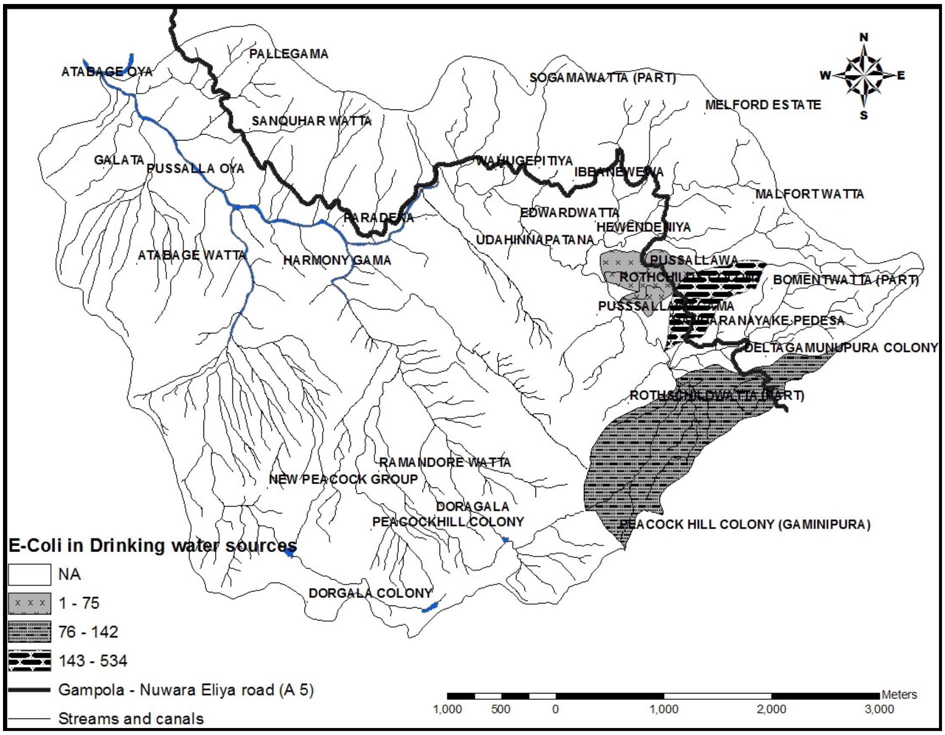

Figure 1: E-coli range of drinking water sources at various places in the catchment.

A network of environment, socioeconomic, and institutional factors are affecting to the prevailing situation. People's practices and the government recommendation for constructing sanitary latrine in a new house is only the water sealed latrine with septic tank and a disposal mechanism (soak to soil or remove using gully). Since the environmental factors such as shallow water table, impermeable or highly permeable soil, shallow bed rock or rocky condition, limited space, sloppiness constrain the function of conventional septic tank. People tend to release their overflows of the septic tank to a drain, since they have no other options mainly due to inappropriate living and/or livelihood. Gully removal is costly and additionally leads to other environmental problems because it is also finally dumped into a bare land or a pit without any treatment. Another interesting situation is that the water sealed latrines are provided to communities who don't have access to adequate water. A best example for above situation is the Rothschild estate. All estates in the catchment have the shortage of water since they are given water for a limited period of time of the day. The question "how they can use the water sealed pour flush latrine without having adequate water?" has not even considered by the management. Therefore, the local context should be taken into account for selecting a sanitation solution. Conventional thinking, lack of innovation of technological solutions considering local situation and knowledge, and poor knowledge transfer has led to these failures of sanitation technologies. The entire issue and root causes network is shown in the Figure 2, as described above.

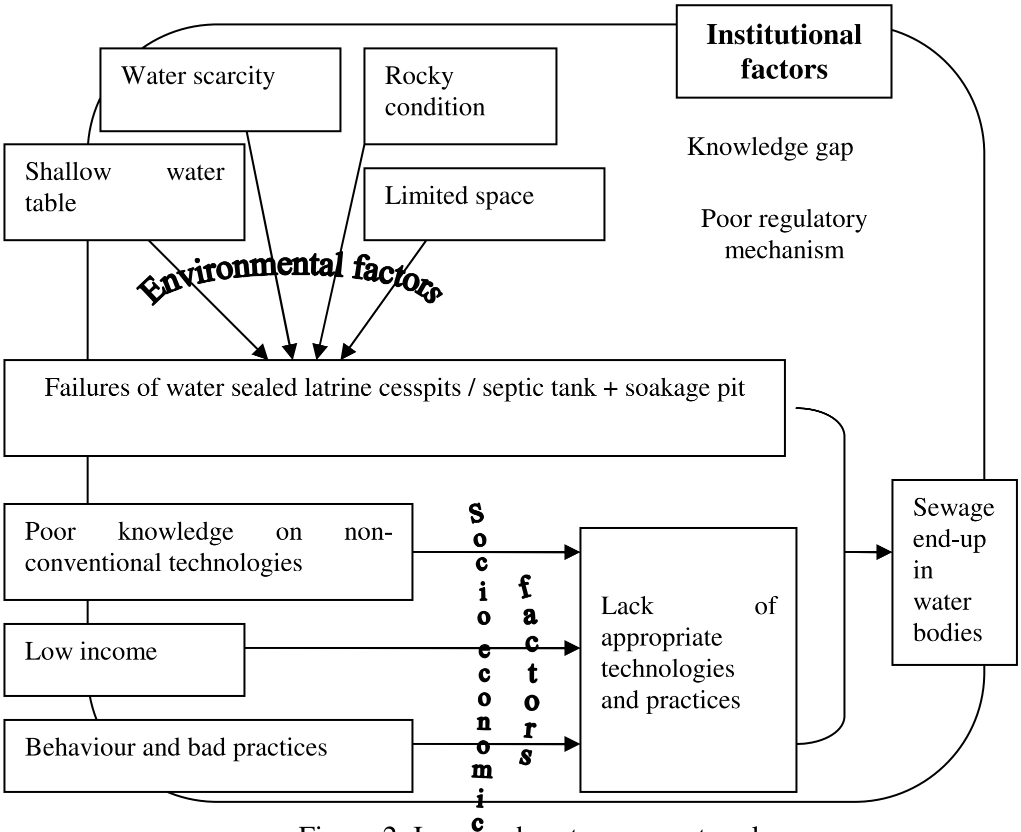

Figure 2: Issue and root causes network.

Applicability of Ecological Sanitation for the Pussella-oya Sub Catchment

What is the difference between conventional sanitation and ecological sanitation?

The conventional sanitation technologies try to get rid of excreta, bury it in the ground and/or dispose to a water body. Since it uses lots of water for flushing, excreta mixed with water which possibly ends up in water bodies (surface and ground), if it is not sanitized before the final disposal. Unlike the conventional sanitation, ecological sanitation closes the loop between sanitation and agriculture, by considering excreta as a valuable resource which can be used as a compost and/or energy source. Ecological sanitation considers excreta as two components where they should not be mixed together; similar to the human plumbing system separates urine and faeces. Since urine is a safe product which is rich in Nitrogen, it can be used as a fertilizer after diluting with water. Faeces contain pathogens and should be sanitized before dispose to the environment. Conventional sanitation mixes above two products together and make sewage smelly and difficult / costly to sanitize. Since ecological sanitation does not allow mixing of faeces with urine and water, sewage will not end-up in a water body. If the separation of these two things is difficult, another option is the production of bio-gas for energy and use the slurry and sludge as a valuable fertilizer. Some people do not like to get rid of the flush toilet, and therefore bio-gas will be a good option to address above issues.

Why ecological sanitation will be a suitable option to solve sanitation problems of the catchment?

As mentioned in the section 2.1, environmental constraints and water insecurity are the most critical issues which hindrance the practice of conventional septic systems. In Pussellawa, conventional system failures are obvious, and everybody suffers due to the smell of overfilled latrines. National Water Supply and Drainage Board and health officials are also struggling in searching a sustainable solution for these sanitation issues. The ecological sanitation will not be costly as septic systems, and has many other benefits. The high-tech centralized solutions can be applied, but the construction and management will be costly because it need very high initial investment and consume a lot of energy. On the other hand, centralized bio-gas production is credible in Pussellawa area if it is designed in a way to maintain all required conditions. Upawansa (2004) discussed the conditions such as temperature, adequate C:N ratio, and water:sewage ratio to be maintained to the optimum level to increase the efficiency. The cost of construction of individual units will be an investment because people can save money making their own bio-energy. Potentially the obtaining contribution from people may be an easy task for a sanitation improvement program which provides them an energy source. Since the Pussellawa is a small township, changing their attitudes toward eco-san toilet will not be an easy task, but it is also credible with awareness and training using urban eco-san models. Ecosan toilet can make as an attached unit to the house with a nice bathroom, commode type pans for elder and/or disable people, squatting pans which has separate washing compartments, if required up to a sophisticated level. Urban agriculture/gardening in small spaces applying collected urine will make the environment attractive because it does not smell when stored separately and apply into the soil (Calvert, 2004). Wahugepitiya is another location where conventional systems are failed due to shallow water table. One eco-san composting toilet model has been established recently in the area.

Many estates produce organic tea and there is a huge potential for compost from eco-san toilets, and sludge and slurry from bio-gas to be applied to tea plantations. Estate management also struggling with the burden of providing water, electricity and other infrastructure facilities to the people free of charge. Additionally, estate women generally allocates half a day for a week to collect firewood. Their valuable working time and energy can be saved by having bio-gas while improving their sanitation and health. Will the water sealed latrine with limited supply of water improve their sanitation and hygiene? No, it will be a burden to the people, and they habitually will go to the stream or a field for defecation making it will be easy anal cleansing at the nearest water source. Ecological solutions with rainwater harvesting structures for water security will be a good alternative to estates, if the communities are educated properly to use it.

Peoples' willingness to adopt eco-san technology should be based on a participatory assessment after they were made aware on it with demonstrations. There are successful cases in Chilaw, Moratuwa, Ratmalana, Matale, Samanturai, Kurunegala and most Tsunami rehabilitation sites in coastal areas according to two practitioners (personnel communication with 'Practical Actions' and Paul Calvert).

Conclusions

Ecological sanitation is a suitable sanitation solution for the Pussella-oya catchment, if it is introduced together with good awareness, training and attitudinal changing activities. Establishment of few models will help to test the applicability and do the technical advancements if needed. It should not be applied blindly to anywhere within the catchment, but carefully taking into consideration the socio-economic, and environmental factors. Acceptability of each communities and individuals should also be considered before application especially in the townships.

Recommendations

- Establishment of few eco-san models.
- Making aware people on ecological sanitation technology.
- Design a suitable technical model to test the bio-gas production using human excreta at field level.
- Participatory assessments for acceptability of ecological sanitation solutions.

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Integrating wastewater agriculture and sanitation

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Abstract

As rain-fed or freshwater irrigated agriculture ceases to be an option, the need arises to look beyond conventional and accepted agricultural practices and to promote more sustainable solutions. The use of wastewater for irrigation is one such option that is being used globally but that is often poorly managed. Driven by rapid urbanization, increasing demand for freshwater and growing wastewater volumes, wastewater is widely used as a low-cost alternative to conventional irrigation water. Despite the associated health and environmental risks, wastewater agriculture supports livelihoods and generates considerable value in urban and peri-urban agriculture.

As a pilot action project, WASPA was initiated in Kurunegala where wastewater is used in agriculture and it rapidly became apparent that certain key aspects are needed to be addressed. The water in the canal used for irrigation comprises of wastewater from commercial establishments of which those disposing of grease and oil are a particular problem, wastewater from city residents, and solid waste that is being discarded into the canal. Hence, although the nutrient rich wastewater is ideal for agriculture, the farmers are in danger of being exposed to waste that may pose a risk to their health or impact on agricultural production. It is clear that tackling any of these would be a major challenge, particularly monitoring the discharge of untreated domestic wastewater; therefore collaboration was sought with local government officials and community members, to build an alliance and to develop a collaborative action plan. It is essential to have collaboration as no project can attempt anything on the city scale without the total support of the local government and the community. The action plan was devised with the aim of creating awareness as it is critical that city residents and businesses are made aware of downstream uses and that they are encouraged to modify their behaviour in ways that protect those uses without compromising their businesses.

The implementation of the action plan is still in the early stage but it can already be seen that there are some interesting outcomes, for example the involvement of managers of commercial units, government officials and farmers. This work therefore provides lessons for the other areas where wastewater is being used unregulated in agriculture.

Introduction

The International Sanitation Year is being celebrated amidst dramatic climactic changes that have affected the livelihoods and nutrition level of people across regions. There is a continuous stream of stories in the news about food shortages and increasing food prices and there is evidence that yields from rain-fed agriculture in some regions could be reduced up to 50% by 2020 (www.bbc.co.uk,). This is coupled with high population growth and increased urbanization, resulting in fewer people working in agriculture and increasing wastewater generation. Urban populations are growing at such a phenomenal rate that in 2008, more than half the world's population will be living in urban areas for the first time in human history. These 3.3 billion people are expected to increase to 5 billion by 2030 by which time the towns and cities of the developing world will make up 80% of the global population (UNFPA, 2007).

These factors suggest that there is a need to look beyond conventional and accepted agricultural practices and to promote more sustainable solutions. The use of wastewater for irrigation is one such option that is being used globally but is often poorly managed. Driven by rapid urbanization, increasing demand for freshwater and growing wastewater volumes, wastewater is widely used as a low-cost alternative to conventional irrigation water. Despite the associated health and environmental risks, wastewater agriculture supports livelihoods and generates considerable value in urban and peri-urban agriculture. Although pervasive, this practice is largely unregulated in low-income countries, and the costs and benefits are poorly understood.

The objective of this paper is to present and share the experiences gained through the safe reuse of wastewater for agriculture based on a pilot study conducted by the Wastewater Agriculture and Sanitation for Poverty Alleviation in Asia (WASPA Asia) Project, which is funded by the European Commission under its Asia Pro Eco II Program and is being undertaken in Sri Lanka and Bangladesh by a consortium of partners. WASPA Asia aims to involve a wide range of stakeholders in developing and testing solutions for sanitation and decentralized wastewater management, and mitigation of health risks from wastewater use in agriculture.

The WASPA project had the objective of contributing to the improvement of livelihoods of urban communities in Bangladesh and Sri Lanka, through integrated sanitation, wastewater management for agricultural use and improved output, reduced environmental pollution and lessened food chain contamination. This was expected to be achieved by, increasing knowledge generation and sharing through the establishment and functioning of multi-stakeholder groups known as Learning Alliances (LAs) and the development and implementation of Participatory Action Plans (PAPs).

As a pilot research project, WASPA is based on the premise that holistic and sustainable wastewater management involves interventions in the whole chain of improved sanitation, contaminant and pollution reduction, and wastewater treatment, disposal, use in agriculture and promotion of hygiene behaviour.

Identifying the problem

The initial project study on the pilot site was focused on the current conditions of the peri-urban areas including demography, sanitation and waste management practices and current agricultural practices; the quality of wastewater being utilized for agriculture.

It was found that about 78% of Kurunegala Town area is drained by two canals; the Wan Ela and the Beu Ela which then flow to the Wilgoda Anicut (weir) (Figure 1). This water is generally used for agriculture activities in the cultivated areas (yayas) of Aswedduma, Dematagahapellessa and Kawudawatte (Nishshanka *et al.*, 2006).

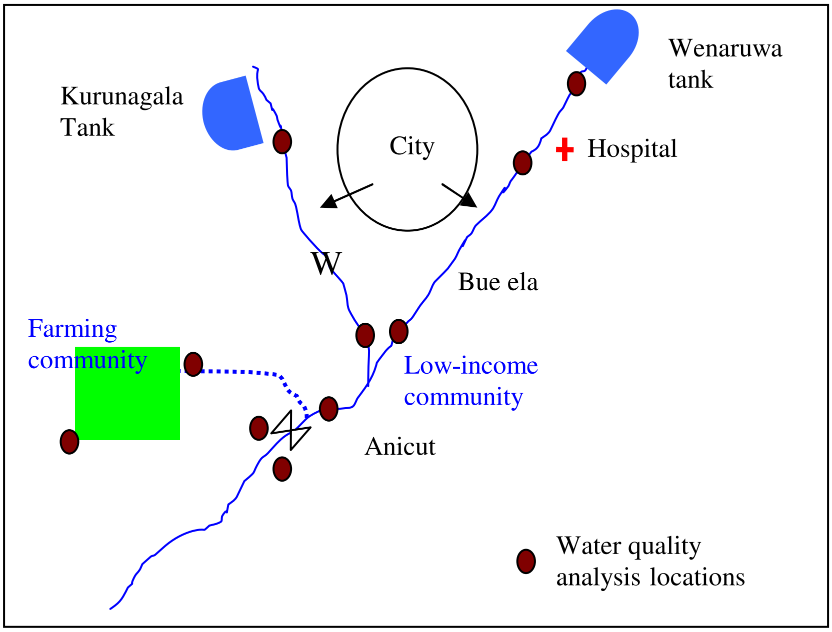

Figure 1: Layout of the study area

The Beu Ela which flows from the Wennaru Wewa, an irrigation tank, was originally used as an irrigation canal but due to the rapid urbanization of Kurunegala, at present it acts as a city drain as well. A study conducted by the National Water Supply and Drainage Board (NWSDB) in 2005 also pointed out that, urban runoff, untreated greywater and sewage are discharged directly into these canals due to the absence of a planned sewage system and limited on-site sanitation facilities. It should be noted that the disposal of sewage into the canal is not legally permitted but regulation of the discharge is extremely difficult. Furthermore, the NWSDB (2005) concludes that the water in the two canals is below the discharge standards of industrial effluents.

The use of wastewater is not the preference of the farmers but they have no alternative. On the positive side, this means that there is ample water for agricultural activities at all times and there is no mismatch between water availability and crop requirements. However, there are obvious issues over water quality.

Further downstream between Kurunegala town and Wilgoda, the canal is subjected to solid waste disposal and liquid waste discharge from the surrounding households, shops, hospitals, service stations and other commercial units. As a result, the farmers are at risk of being exposed to various pathogens which may affect their health and sharp objects which can make wounds.

There is also evidence to suggest that the closing of the anicut to retain irrigation water results in stagnation and some localized flooding, including flooding of residential areas making health and environment hazards. In particularly, mosquito nuisances have been mentioned by community members interviewed, who stated that a few people in the area have Filariasis (Nishshanka *et al*., 2006).

The project identified both point and non point source of pollution including:

- Small scale industrial effluent discharge to canals;
- Wastewater and sewage discharge to canals;
- Dumping of solid waste into canals;
- Open defecation on canal banks and in open areas that washes into the canal;
- Urban runoff;
- Chemicals and other wastes from upstream agriculture lands (Dissanayake *et al*., 2007).

The baseline survey on the industrial and commercial units identified hospitals, vehicle service stations, slaughter houses, meat stalls, hotels and restaurants, schools, technical colleges and tuition classes, and residences as significant sources of pollution in the area. The National Teaching Hospital of Kurunegala (NTHK) was also identified as a major source of pollution due to malfunctioning of its waste treatment plant.

The major health risk associated with the use of wastewater in agriculture in the project area was determined to be the high level of faecal contamination. However, since the wastewater is mainly used for growing paddy, the health risks exist for the farmers and labourers that are in direct contact with the wastewater and not the consumers, as rice is processed and always eaten cooked. There are a very limited number of vegetable patches along the canal banks which may pose more of a health risk to consumers. These findings show that there is a need to minimize the health risks faced by agricultural workers and their families and also the community living alongside the canal that use contaminated groundwater for washing and cooking.

Developing solutions – A collaborative approach

The development of the WASPA Learning Alliance (LA) was a key activity designed to maintain the sustainability of project interventions. The LA was brought together to discuss the findings of the initial assessment and to agree on which were the main issues that needed to be addressed and which could feasibly be addressed within the project period of three years. They collaboratively developed specific action plans to tackle these problems. The action plans required considerable continued collaboration between the stakeholders to ensure that they would be implemented and sustained.

One of these collaborations is between the local Agrarian Services Department, the Industrial Services Bureau (ISB) Kurunegala and the Wilgoda Farmer' Organization, which has been established to improve fertilizer guidance. Another is between the NTHK, the Municipal Council and the National Cleaner Production Centre (NCPC) who are all working to improve wastewater management in the hospital.

The LA members meet once in two months for project activity reviews and discussion of other pressing matters of their area. The LA also consists of a Core Group of five members of the LA. The core group that works hand in hand with the communities in question meets once a month for project and activity reviews and to plan what needs to be done next.

Integrated solutions

The plans developed by the stakeholders fell into three key areas.

1. Improving awareness of health risks among the farming families and introducing hygienic practices to reduce the risk.
2. Minimizing the waste reaching the fields, whist maintaining a sufficient quantity of wastewater.
3. Improving agricultural output by developing and disseminating improved fertilizer guidance that takes into consideration the level of nutrients already present in the wastewater.

Improving wastewater handling

Educating the farming community on hygiene issues particularly relating to wastewater handling and use was considered essential as this is perhaps the only aspect that the farmers have full control over. It was found that farmers had only a limited awareness about the possible health risks including dermatitis that can result from prolonged exposure to wastewater and gastro-intestinal infections that can result from, amongst other things, not washing hands after handling wastewater and then eating. The farmers were therefore taught to always wash their hands and legs in clean water when they left the fields; to avoid putting their hands in their mouths when working in the fields, and not to consume food in the fields unless they were able to wash their hands with clean water.

Preventing Waste from Reaching Fields

As solid waste was identified as a problem, it was suggested that in addition to campaigns to reduce the quantity of solid waste being disposed into the canal, there should also be a system to remove it before reaching the fields. A waste trap was designed in collaboration with the Irrigation Department and farmers and approval was obtained from the Municipal Council. It was also agreed that the trap would be cleaned by the farmers who are members of the Wilgoda Farmers' Association. They were happy to undertake this role as they currently spend many hours removing solid waste such as plastic bags and old containers from their field drains. Cleaning the trap should be less time consuming and should give them more time to spend tending their fields or undertaking other productive activities. This is essential as most of the farmers grow paddy for subsistence and have additional income sources.

Reducing waste production in commercial units and industries was also an essential component as both the farmers and the Municipal Council were concerned about the oil and grease in the wastewater, as well as waste from hospitals. This work started slowly as many businesses were unable to see the benefits for them and considered that it would be a costly exercise. The Kurunegala Teaching Hospital was however the first organization to take an interest in the idea of introducing cleaner production options as they saw this as a way of reducing consumption and thereby costs; they were also aware of their responsibility of not polluting the waterways.

This component of the work really took off when a workshop was held and a number of industry representatives made presentations about the benefits that their businesses have received from introducing cleaner production and wastewater treatment. The participants were also provided with guidance booklets appropriate for the type of industry:

1. A Guide for Vehicle Service Station Owners and Managers - a Guide to Onsite Wastewater Management for Industrial and Commercial Establishments
2. A Guide for Hotel and Restaurant Owners and Managers- a Guide to Onsite Wastewater Management for Industrial and Commercial Establishments
3. A Guide for Hospitals - a Guide to Onsite Wastewater Management for Industrial and Commercial Establishments

The residents of Kurunegala city are also responsible for waste production but are a much larger group and are therefore more difficult to reach. The project team and Learning Alliance therefore initiated work with communities that live adjacent to the canal. They were asked to take part in awareness raising and sensitizing activities regarding the impacts of their action on downstream farmers. They will also take part in an activity to compost organic waste and to grow a hedge or live fence, to prevent people from going directly to the canal and dumping their rubbish. This idea was enthusiastically welcomed by the housewives.

The Pradeshiya Sabha, Kurunegala will augment this activity by working with the project team to create and erect sign boards to remind people of the impacts of waste disposal in the canals.

Extending this message and providing alternative options to the other residents will be more difficult but the Medical Officer for Health (MOH) and the Public Health Inspectors (PHIs) of the Kurunegala Municipal Council (MC), along with the Central Environment Authority Kurunegala Brach have agreed to take responsibility for spreading this message and attempting to enforce compliance with regulations.

Kurunegala is a fast developing city and the main transit town of the area. Thousands of people who pass through the town daily do not pay much attention to the cleanness of the town due to their negligence or lack of awareness. Discussions are currently underway with LA members and the MC to select and develop a programme to be implemented in a selected area to create a model of waste-free area in Kurunegala; it is likely that this will be the bus station.

Managing wastewater for agricultural production

As already stated, wastewater can be extremely beneficial for agricultural production because it provides a source of water throughout the year that is full of nutrients. However, these benefits need to be maximized through effective management. On other words, the farmers need to be aware of the quantities of nutrients reaching their fields so that they can alter the quantities of fertilizers that they apply. If they over fertilize they can face problems such as excessive vegetative growth, low grain yield and increased pest attack, and downstream environmental impacts.

The project team has therefore been working with the local Agrarian Services Department, the Industrial Services Bureau (ISB) Kurunegala and the Wilgoda Farmer' Organization to sample water and soil, for existing nutrient levels in order to develop improved fertilizer recommendations.

Outcomes and problems

Institutional issues and participation

While the waste trap work was being undertaken, the three key people involved from the Irrigation Department were transferred. It lead to stagnate the work for sometime due to the time taken by the new director, deputy director and chief engineer to pick up with the discussions. This highlights the need for the organization to get involved as a whole or to get the involvement of at least several members of the organization, to ensure that there is always someone who is aware of the project and can take over the supporting role. This is clearly not easy but efforts need to be made to encourage collaborators to inform other members of their organization in a formal and structured way, either through a letter or through short meetings. It has been agreed that the project team will produce a short newsletter, which may help to support this process.

Similar problems exist at the community level where the involvement of the farmers in the actual construction of the waste trap was insufficient and was inadequately planned. This also partly contributed to the delay experienced when the Irrigation Department changed its staff since farmers lost their interest as the delay continued. No clear work plan was developed with the farmers to say who would contribute labor and at what time. Hence, the project team had to hire help as there were very few volunteers that turned up occasionally from the side of the farmers.

Clearly there is a need to strengthen the existing capacity of the Wilgoda Farmers' Organization so that they can work together more effectively. This aspect is essential as the routine maintenance of the garbage trap will be their responsibility.

Development of the LA

The process of developing the multi-stakeholder platforms was perhaps the most challenging. The initial obstacle was that wastewater agriculture was not an issue for many of them to consider, even through their functions or activities are directly overlapped with this issue. Secondly, many of the stakeholders had never been part of such a collaborative group and therefore it was at times difficult to get them to participate and even more difficult to get them to make decisions. This is gradually being overcome but still requires considerable facilitation from the project team.

Conclusions

Wastewater agriculture is not a topic that has been extensively tackled in Sri Lanka but it is of increasing importance globally, to address water scarcity and food security, and will be just as important in Sri Lanka as elsewhere. The nature of the issue is such that many very different groups of people can contribute to problems associated with wastewater use, and therefore must become part of the solution if sustainable changes are to be made to improve the quality of wastewater, reduce the health risks and subsequently to increase food production. These groups include farmers, urban residents, businesses and industries, local government and agriculture departments to name but a few. Brining these groups together is however not easy and requires significant facilitation on the part of the project team. This role has been played by the WASPA project team for several months and there is evidence that collaboration between stakeholders is improving. However, whether this is enough to sustain interventions and to result in long term changes in practices and impacts has yet to be seen.

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