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Review Paper

REVIEW OF SUSTAINABLE WASTE WATER TREATMENT OPTION FOR URBAN SANITATION FACILITIES IN DEVELOPING COUTRIES, CASE STUDY: UPPER BHIMA BASIN, INDIA

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Abstract: Generation and accumulation of domestic waste from fast growing human settlements is becoming a major environment and health problem in developing country like India. The problem is becoming very acute in urban areas. Appropriate management of these wastes is very important for a positive improvement in the quality of life in cities. With unprecedented growth of cities, the present waste management facilities have been found to be very haphazard and inadequate. Conventional methodologies like conventional sewerage systems presently in use are grossly inadequate to manage the generated waste. As a result, untreated domestic waste finds direct access to water systems or lies untreated on the land surface. Solid waste management also is a major problem in virtually all the cities. This is grossly detrimental to the environment and to the health of the community. Therefore, it becomes necessary to take an overview of the existing situation and to think about appropriate solutions and alternative technologies for the management of these wastes. This paper will highlight one of such treatment option that has been employed in Pune District of Maharashtra State (India).

Keywords: Sanitation, decentralized on-site, integrated waste management

INTRODUCTION

Urban Water Supply and Sanitation are important basic needs for the improvement of the quality of life and enhancement of productive efficiency of the people. In urban areas, water is tapped for domestic use and industrial use from rivers, streams, wells and lakes. Almost 80% of the water supplied for domestic use comes out as wastewater. In most of the cases, wastewater is let untreated or partially treated and it either sinks into ground as a potential pollutant of ground water or is discharged into the natural drainage system causing pollution in downstream areas.

Municipal Sewage may be defined as “Waste (mostly liquid) originating from a community; may be composed of domestic wastewaters and / or industrial discharges”. It is a major source of water pollution in India, particularly in and around large urban centers. In India, about 78% of the urban population has access to safe drinking water and about 38% of the urban population has access to sanitation services. Water requirement for various sectors is depicted in Table 1. This indicates that the demand for drinking water is increasing, since the population in urban areas is increasing. The increasing trend for urbanization is shown in Table 2.

Table 1: Water requirement for various sectors

Sector	Water Demand in km^3 (or BCM)					
	Standing Sub-Committee of MoWR			NCIWRD		
Year	2010	2025	2050	2010	2025	2050
Irrigation	688	910	1072	557	611	807
Drinking Water	56	73	102	43	62	111
Industry	12	23	63	37	67	81
Energy	5	15	130	19	33	70
Others	52	72	80	54	70	111
Total	813	1093	1447	710	843	1180

Source: Website of Ministry of Water Resources (MoWR), Govt. of India, National Council for Integrated Water Resource and Development (NCIWRD)

Table 2: Increasing trend for urbanization

Serial No.	Census Year	Population	Urban Population of Class-I cities	% Urban Population of Class-I cities
1	1901	25616051	6586347	25.7
2	1911	25580199	6955756	27.2
3	1921	27691306	8142241	29.4
4	1931	32976018	10090279	30.6
5	1941	43558665	16519922	37.9
6	1951	61629646	27308404	44.3
7	1961	77562000	39380309	50.7
8	1971	106966534	60123375	56.2
9	1981	156188507	94292998	60.3
10	1991	217611000	138802000	63.7
11	2001	286119689	178426355	64.6

With the enhancement of drinking water supply to urban areas, the wastewater generation is increasing. If such wastewater is not collected, treated and disposed properly, it will create directly, contribution to the locally available freshwater supplies. Additionally, the cumulative results of untreated wastewater can have broad degenerative effects on both public health and ecosystem.

Urban Environmental Management is one of the most pressing issue as the urbanization trend continues globally. Among the challenges faced by urban planners, is the need to ensure ongoing basic human services as the provision of water and sanitation. The under-management of domestic wastewater in many southern urban areas presents a major challenge. The accumulation of human waste is constant and unmanaged wastewater directly contributes to the contamination of locally available fresh water supplies. Additionally, the cumulative results of unmanaged wastewater can have broad degenerative effects on both public and ecosystem health.

SCENARION IN UPPER BHIMA BASIN

Location

Upper Bhima Basin (UBB) is located on the western side of the South Indian Peninsula. Bhima River, a tributary of east flowing Krishna River, rises at an elevation of over 1100 m in the N-S Sahyadri mountain range, flows for a distance of 305 km in southeasterly direction upto Ujjani dam, having full supply level of 497m and traverses 140km further to meet Krishna River in the Andhra Pradesh state at an elevation of 343m. Upper Bhima Basin i.e. catchment area of Ujjani dam , located on the leeward side of Sahyadri mountain range extends over 14,712 sqkm and is fed by 10 major tributaries having total length of 1140km.Ujjani lake having water spread of about 290 sqkm has gross storage of 3320 Mcum and live storage of 1518 Mcum. A link canal / tunnel diverts lake water by gravity to utilize 89 Mcum of water to irrigate 48000 ha land under seasonal crop by lift irrigation schemes in the adjoining Sina Valley. Balance water of the lake provides seasonal irrigation to about 1,26,000 ha of drought prone area in Solapur district by means of left bank and right bank canals, in addition to providing water to Solapur city and industrial area around it .

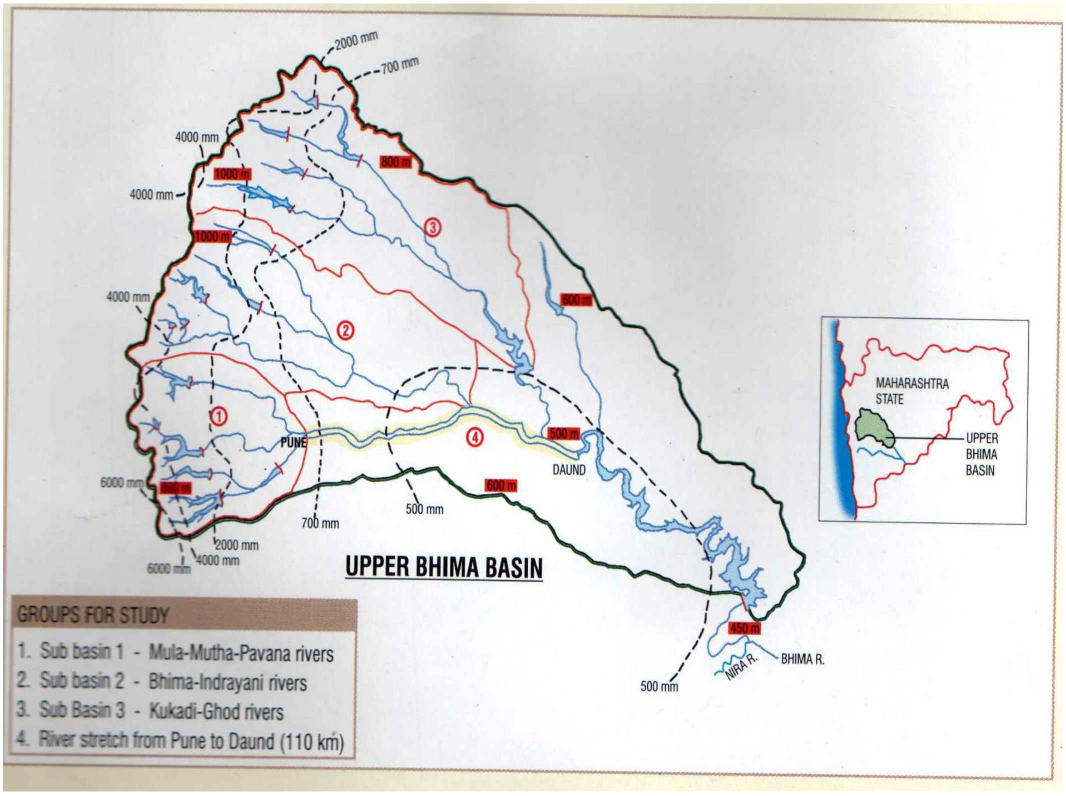

Fig. 1: Schematic sketch of upper bhima basin.

Climate

Catchment receives S-W monsoon precipitation having highest of about 6000 mm near ridge at the southern end but reduces to about 2000mm within a distance of 20 km towards East. Nearly 60% of the catchment area in the lower part receives precipitation less than 600 mm and is often subjected to serve drought conditions. Winter season is moderate from November to February with recorded lowest temperature of 3^0C. Nearly 50% of the total annual evaporation occurs in 4 summer months.

Topography

Hilly areas in the high rainfall zone along eastern slope of the Sahyadri mountain range is followed by moderately undulating land having rolling topography and interspersed frequently by small streams and rivers. All the river courses are deep and well defined. Land slopes are steep in hilly areas , moderate in the plain and flatter on the banks of the streams. Flood problem is hence localized mainly to the low lying areas in the cities and towns. Most of the rivers are ephemeral and do not have any flow in the summer season.

Geology

Entire catchment is having sub strata of igneous basalt flows of course grained, sparsely jointed amygdaloidal basalt (secondary filling of amethyst and zeolite) and fine grained close joined basalt. Intertrappen red bole layers are met with at some places. Lava flows are cut across at some places by dolerite dykes. Shallow course grained, sparsely jointed amygdaloidal basalt and fine grained close jointed basalt.

Table 3: Soil Type in UBB

Soil Type	Percentage
Reddish brown soil along hill slopes	38
Coarse grained shallow soil	12
Medium deep black soil	26
Deep black soil	24

Landuse pattern

The total land area in the basin is 14,71,000 Ha. There are many on-going activities in the basin for which the land has been allotted to, ranging from land used for cultivation, forest land and land used for non-agricultural usage etc. The breakup of land usage for various activities in the basin are depicted in Table 4 below.

Demographic details

As per 1991 census, total population of the UBB was 5.26 millions (2.74 M urban and 2.52M rural). As per projections computed by Maharashtra Water and Irrigation Commission Report (1999), basin population is expected to rise to 15.73 M by 2030. Rural population would double during 40 years but urban population would be nearly 4 times during this period. As per 2001 census report there has been 30.8 percent increase in the population of Pune district since 1991. The rate is slightly less than 32.85 percent increase in 1981-91 period .Population of draft and mulch animals (cow and buffalos) was 1.01 M and that of sheep and goats was 0.89 M as per 1991 census.

Table 4: Land Use Pattern in UBB

Details	Area in ha	Percentage of geographical area
1. Geographical area	14,71,000	100.0
2. Forest Land	1,49,000	10.1
3. Land not available for cultivation	2,00,000	13.6
3a. Waste land	1,32,000	
3b. Land under nonagricultural use	68,000	
4. Cultivable fallow	31,000	2.1
5. Pasture land	63,000	4.3
6. Other fallow land	75,000	5.1
7. Land under plough	9,53,000	64.8
8. Cultivable land	11,22,000	
9. Doubled cropped area	1,64,000	
10.Total area under crop	11,17,000	
11.Cropping intensity	117	

Surface water resources in the basin

Based on 50 year dependability value of 7402 Mcum, availability of water per capita as per 1991 census works out to be 1407 cum/year and availability per hectare of cultivable land works out to be 6597 cum/year. Position of completed, in- progress and future irrigation projects in the catchment of Ujjani dam (UBB) is shown below.

Table 5: Details of Irrigation Projects in UBB

Type of project	Irrigation potential of each (in ha)	Completed projects (No.)	In progress projects (No.)	Total projects (No.)	Total irrigation potential (in ha)	Future projects (No.)	Irrigation potential (in ha)
Major	> 10,000	7	12	19	3,51,500	-	-
Medium	2000 to 10,000	1	3	4	17,000	-	-
Minor	<2,000	109	59	168	85000	42	6500
K.T. weir	<2000	25	7	32		3	
Total		142	81	223	453500	45	6500

Ground water resources in the basin

High rainfall in the upper reaches of the catchment is ineffective in recharging groundwater because of the unfavorable geological substrata conditions, where scanty rainfall in the lower reaches contributes much less to the groundwater recharge. Out of 63 GSDA (Ground Water Survey and Development Agency), watersheds in UBB, work is planned in 38 GSDA watersheds covering areas of 8,60,000 ha. Present position of works is shown in Table 6.

Table 6: Watersheds Developed in UBB By GSDA

GSDA Watershed		Completed mini watershed		In-progress mini watershed			
No	Area in ha	No.	Area in ha	No.	Area treated in ha	Balance area in ha	Total area in ha
38	8,60,000	128	54,000	684	1,29,000	3,59,000	4,88,000

Creation of irrigation potential

Ultimate irrigation potential in UBB is as follows. Potential from surface irrigation scheme - 4,60,000 ha (41%). Groundwater potential due to natural and applied irrigation recharge – 1,60,000 ha (14%).

Ground water potential due to additional recharges from watershed development works- 86,000 ha (8%). Total irrigation potential is 7,06,000ha (63% of 11,22,000 ha).

NEED FOR ASSESSING SUSTAINABLE SANITATION OPTIONS IN UPPER BHIMA BASIN

It has been established that, the water availability in Upper Bhima Basin is under stress and hence all the water supply and sanitation projects shall be planned in the most possible sustainable way. In Upper Bhima Basin, the main domestic wastewater pollution is from major cities like Pune and Pimpri Chinchwad, which contribute together to more than 50% of domestic wastewater generation in the entire area. Although the corporations have separate wastewater treatment plants, they are unable to cope up with the ever increasing population and consequently, the waste water generated from the area. Hence a separate study was carried out to check the suitability of low cost sanitation options for this area. These options have been in practice for more than 20 years but are more popular with the rural and peri-urban areas of UBB. However, the same can be used even for urban areas, as the Urban Local Bodies are finding it difficult to meet with the ever-increasing demand for wastewater management, both in terms of applying the most sustainable technology as well providing huge capital cost and running cost for such high- end technologies. Hence there is a need to assess the Sustainability of technologies. One such option is discussed herewith.

What is sanitation?

Sanitation is commonly defined as “Adoption of measures to eliminate unhealthy elements especially with regard to dirt and infection.” Thus, the treatment of waste so as to prevent spread of pathogens becomes a very important parameter for deciding the appropriateness of the technology. If this requirement is not met, the technology in use will have to be reviewed suitably. In the present urban situation, we may try to have a look at the technologies in use from this point of view as well.

Types of waste

A very practical action oriented classification of urban domestic waste could be done in three important groups: 1) Human excreta, 2) Non excretal solid wastes (Garbage), 3) Non excretal liquid waste (Sullage). Where the conventional sewerage system has been installed, human excreta and sullage are combined so that the sullage acts as a carrier for human excreta and the total liquid flow is termed as sewage. These wastes need to be treated in a sanitary manner.

Prevailing conventional systems

The prevailing conventional sewage systems and solid waste management systems are grossly inadequate for managing the load of these domestic wastes from burgeoning cities. A review of the existing conditions in four major metros and large municipal corporations confirms this. Further, due to very high capital cost for establishing such systems, it is becoming very difficult to expand or newly establish these systems, in order to keep pace with growth of the cities. Their operation and maintenance costs are also very prohibitive.

Similarly, solid waste management through the conventional systems is also becoming difficult. Collection and transportation has become a major problem. As far as the final treatment is concerned, high-tech mechanized processes are very capital intensive and unsuitable for the available kind of manpower.

The waste management methodologies cannot be only affluent, city dweller oriented. Low-income urban and peri-urban areas will have to be considered. Therefore, it will not be feasible to cover the total city limits with these capital intensive, maintenance intensive, high-tech methodologies. At present, only about 50% population is being covered with these conventional systems, nearly half the population of the cities remains uncovered.

As stated earlier, even in the urban areas covered with conventional sewage systems, the capacity for final treatment of domestic waste is grossly inadequate. As a result, untreated sewage is let out in the water bodies like rivers or seas. Natural water purification process in these water bodies is inadequate to take care of such massive waste. Thus river beds are day by day being converted to virtually open sewers. The problem is compounded by the construction of dams and bunds in the river course. Large river cleaning projects have been found to be inadequate because these projects are mainly concentrated on establishing conventional sewage systems in townships along the course of the rivers. Obviously, limited funds available with them do not allow them to take in the entire burden. Thus, various river cleaning projects are turning into media gimmicks. For example, in spite of the Ganga cleaning project, the Ganga has not changed much.

Apropriate low cost sanitation technology

Considering the fact that about 50% of urban low income and peri-urban population in the cities is remaining uncovered by conventional sewage systems as far as the domestic waste management is concerned, and that, in most of the conventional sewage systems, the final treatment of sewage is not very satisfactory and very inadequate, (on an average, in most of the cities only about 30% sewage is treated), it is necessary to search for new unconventional appropriate technologies for strengthening the current waste management efforts. Low cost appropriate sanitation technologies are likely to provide an answer. In the given circumstances, these will provide wider coverage at low cost.

“Decentralised on site” management

If these technologies can possibly be used in a decentralized manner, the system and transportation cost would be reduced and management would become simpler and easier. Further, if the systems provide on-site final treatment, the process can become hygienic in the end and environment friendly.

"The decentralized on site" management systems will also provide hygienically and environmentally safe end products which can be conveniently recycled and reused. This concept of "DECENTRALISED ON SITE" waste management gives a totally new dimension to the practice of using conventional methodologies for managing urban waste. This kind of management systems may prove to be very useful where sewerage system is not available e. g. periurban areas, new housing societies low income group habitats etc. Even in core areas where conventional sewerage is available, in individual bungalows; housing societies etc. these technologies will prove to be very useful and appropriate.

Liquid waste (sullage) management

Wherever possible, sewage can be collected separately from sullage. This can be done where open land is available. This will help in reducing the load on conventional sewerage systems. Following may be some of the useful technologies: 1) Soak pit, 2) Leach pit, 3) Gardening: By treating the sullage in grease trap followed by stabilization tank. This can be done very conveniently in individual bungalows, societies, institutions etc. This will also reduce the use of treated water for gardening. Depending on the suitability, any of these technologies would be useful in urban low income and peri-urban areas. It may be added that the use of such suitable technology at the domestic level, would be ideal. This can lead to 'ZERO COMMUNITY SULLAGE' or 'MINIMUM COMMUNITY SULLAGE'. This concept needs to be established in the community.

Human excreta management

In urban areas, where the conventional sewerage system exists, human excreta are carried away in the form of sewage. However, the conventional sewerage system is available mostly in core areas of the cities. Nearly 50% population in the city has no access to conventional sewerage system. In urban low income and periurban areas human excreta is managed through 'On Site' anaerobic digestion systems like septic tanks or aqua privies. In these systems the effluent (which is not pathogen free) is managed improperly. Thus, these systems become sources of pathogen spread and land pollution. In this situation, it may be useful to allow newer technologies like biomethanation technologies, to interpose in the sewerage system at the source in various societies, bungalows etc. The treated effluent is let out in the sewerage systems. Where sewerage systems are not available, integrated waste management systems 'On Site' may be tried.

For peripheral urban areas, two pit latrine technology will prove to be cheap and convenient. In fact, even in bungalows surrounded by open land and with limited inhabitants, two pit technology would be very suitable. From the health point of view also, it will be very suitable. Two pit latrine technology 'On Site' is decidedly a better option, as it is at a low cost, easy for construction, easy for maintenance, suitable from health point of view and productive for manure. There are quite a lot of misgivings about this technology. However, this technology has proved its place, in management of human excreta.

Further, as stated above, the night soil based biogas plant is another very appropriate technology even in the urban areas. It's potential as a source of fuel (energy) makes it highly sustainable. The results from such biogas plants constructed in the urban areas are very encouraging. Such plants have also been established in industries. The results from such plants are also very good.

DOSIWAM (Decentralized On Site Integrated Waste Management)

In recent years, Integrated Waste Management system at source, have been developed (as low cost as possible) based on either aerobic or anaerobic biodigestion 'Onsite' with maximum possible recycling and reuse. In these systems, all wastes are taken care of by using technologies which work in tandem as complementary to each other. Thus, in these systems total recycling of end products from total waste treatment is done.

In this system, human night soil is led separately to a biogas plant. The gas from the biogas plant is taken to kitchen. The effluent from biogas plant is combined with sullage from bathrooms, kitchens etc. The total effluent is then passed through grease trap or intercepting tank. From there, the effluent is led to multi-chambered stabilizing tank. The water coming out from this tank has very low BOD, so that the water becomes suitable for reuse in gardening and for irrigation.

The solid waste is sorted out in biodegradable and non biodegradable components. Non biodegradable component goes for recycling, and biodegradable component is vermi-composted. The recovered manure is used on the same land where the garden has been established. Thus, with this system, all the waste is taken care of and fully recycled and reused, so that , not a grain of waste matter, nor a drop of water leaves the premises of the particular house or institution. Such technologies have been established such systems in residential institutions, schools, industries, etc. The results are extremely satisfactory. Such systems can be conveniently replicated in bungalows and houses where open land is available. The system can work very effectively in various housing societies, schools etc.

Sum up

The conventional waste management systems in the cities have their limitations in total coverage of the fast expanding urban population. Therefore it may be necessary to think of the use of alternative technologies, so that the total urban waste is managed hygienically and in an environment friendly manner. Therefore, use of decentralized 'Onsite' management of waste needs to be considered. Appropriate suitable technologies are available.

Thus, it is felt that a judicious use of low cost waste management technologies in combination with conventional waste management technologies will go a long way in minimizing land and water pollution, thus working towards a better environment for the future. An off shoot from Gandhian philosophy and Appasaheb Patwardhan's thinking on Bhangi Mukti and sanitation is the thought that, 'Expecting some one else to manage one's own waste is immoral and a blot on human dignity.' This would mean that the management of waste 'On site' as far as possible at the domestic level is ideal. Where it is not practical, it may be desirable to opt for appropriate low cost technologies in a decentralized manner and to use the end products productively.This would result in converting the pollution into prosperity, wealth and health.

CASE STUDY: PROJECT FOR 'MAHER', VADHU BK (PUNE, MAHARASHTRA, INDIA)

A public charitable Trust 'Maher' expressed willingness to establish an integrated waste management system to manage all the waste generated in their premises and land at Vadhu Bk, Tal. Shirur", Dist Pune. The institution provides shelter and development facilities for orphaned and deprived children. Further, it provides shelter and helps in overcoming family relationship problems of women. It also undertakes social service work in neighbouring villages. At present, there are about 200 inmates and staff members who are resident in the institution. 'The institution had been facing waste management problems. The issue was discussed with authorities of' Maher' .There was a general agreement that, establishing an Integrated Waste Management system for all the waste generated in their institution, will result in environmental improvements in the campus.

Previous waste management situation

Management of human night soil was a positive problem. Five toilets with flushing system were provided in the buildings. All these toilets were supposed to be connected to a common septic tank. However, due to initial faulty designing, the septic tank was located at a location, which was nearly four feet above, the toilet floor level. When this problem was noticed, a R.C.C. pipe septic tank was placed in the other direction. This tank had a very low capacity. As a result, raw night-soil was coming out from the septic tank. This was a major public nuisance. The villagers were complaining about these conditions as the smell and dirt pervaded adjacent parts of the villagers.

Sullage water in the complex amounted to about 6000 litres per day. This originated from washing platform, utensil cleaning platform, kitchen waste water, bathrooms. This sullage was laid to soak pit of 4ft x 3ft size. This soak pit was obviously inadequate and the sullage overflowed from the soak pit .This overflow went to the neighbour's farm and caused water togging in about two Gunthas (@ 2000 sq. feet) of his land. Obviously he complained and threatened repeatedly.

Non excretal solid waste (garbage) from the institution was being dumped in a heap. Part of it was getting scattered around the campus, some getting composted, and whatever remained was taken care of by nature.

Objectives for integrated waste management

1. Usually, waste management is thought of when waste material starts becoming a nuisance. During construction and planning stages, detailed thought is not given to the likely quantities of generated waste. Provisions are made only for carrying away human excreta and sullage water. Further, treatment facilities are inadequate and haphazard or may be non-existent. This inadequacy is covered under the garb of paucity of funds.
2. In this project, it was proposed to take a comprehensive review of generated waste in campus in totality .The future probable expansion in the campus-planning was kept in mind so as to allow the expansion of systems whenever necessary.
3. Hygienically oriented appropriate low cost processes, to take care of all types of generated waste, leading to reuse and recycling were suggested. Thus, the campus was to be provided with an integrated total waste management system, so as to generate wealth from waste.
4. It was visualized that total management of mainly following types of wastes viz. a) human excreta, b) non-excretal sullage water c) non-excretal solid garbage, will be considered. .
5. Human night-soil was to be collected without mixing it with sullage. It was to be anaerobically digested adequately, so that the effluent becomes hygienically safe. Biogas was to be recovered from digestion. It was to be used as fuel.
6. Initially, the overflows and waste water were flowing at random. It was to be ensured that this pollution was prevented.
7. Biogas plant effluent and sullage were to be recycled for gardening or kitchen garden.
8. Garbage was to be utilised to produce manure, which could be used for kitchen garden.
9. The proposed technologies were planned to be appropriate in the given situation. These must be as low a cost as possible.
10. Process was to be established in such a way that they were complementary to each other.

Newly established integrated waste management system

For human night-soil management, a) toilets were modified suitably; b) flow from all the toilets was collected by laying a new pipeline inclusive of chambers. This night-soil was laid to a night soil based biogas plant. The biogas generated in the plant has been led to a kitchen where it is used for cooking. Effluent from biogas plant has been combined with sullage from washing platform, utensil cleaning platform, kitchen, and bathrooms. This sullage is carried forward through intercepting chamber. Finally it is carried to grease trap. Effluent from grease trap is mixed with fresh water and is subsequently used for irrigating vegetables garden. Garbage from institution is collected in vermin-compost pits and vermin-composted. The end product in the form of manure is utilised in vegetable garden as manure.

With this kind of effluent management it was found that initial BOD was reduced from 300 to about 65, thus stabilizing wastewater. Use of stabilized sullage water and manure from vermin-compost pits in vegetable garden produces vegetables adequate for inmates in the institution. Thus, all the waste in the campus is fully recycled by way of complementary technologies. Thus, waste is converted to wealth. Now, not a drop of waste water nor a bit of garbage goes out from the campus. It is recycled hygienically and productively.

The system has been operational for about three years. The biogas is now used in the kitchen. With the use of fertilizer from vermin-compost pits and the stabilised waste water obtained from the process, the institution is tending a vegetable and fruit garden. The produce from this garden meets the vegetable requirements of the institution.

This project has been a successful demonstration of the concept of "Integrated Waste Management". It has shown that so called waste is not a throwaway material with a nuisance value. By using natural eco-friendly processes, the waste from growing human habitations can be converted to wealth in environmental friendly way by adopting suitable and appropriate technologies. The management can be effectively done in a sustainable way 'ON SITE', in a decentralised manner by the use of low cost appropriate technologies, This could be one of the options for waste management for developing countries which have limited financial resources but abundant endowment of tropical climate.

Subsequent scaling up

About a year back the institution was expanded. Six more building and about eight latrines have been added. The numbers of inmates are going to be near about 400. Because of the excellent experience from the established waste management system, it was decided to extend the same system to these additional buildings. The scaling up has now been done to cover all new buildings and additional inmates. The expanded system also is functioning very satisfactorily

Potential for integrated waste management systems

This kind of Integrated Waste Management methodology can be very useful in various residential institutions, indus1ries, housing societies etc. Small villages could be successfully covered with such systems after adequate efforts at community awareness and community participation.

Biomethanation options – sustainable option for waste management

As stated earlier, there could be many such bulk organic waste producing establishments where, 'ON SITE ' projects could be established. Such projects could be "citizen or establishment managed", with technological and coordination inputs from municipal authorities. This kind of decentralized 'ON SITE' solid and liquid waste management could relieve the management burden on municipal systems. It may be necessary to undertake active IEC and administrative efforts to popularise such methodologies. Print and audio visual media could be conveniently utilised. If several institutions, societies or industrial establishments etc. come forward for such decentralized "citizen-managed" waste management projects, incentives in some form and relevant tax relief can help in popularising such projects. This will reduce the load of municipal waste management systems.

Summary

After carrying out the techno-economic evaluation of the integrated on-site management technique used at the above site and on comparing the results with the conventional waste water treatment plants in Urban area like Pune city in Upper Bhima Basin, it is established that the above mentioned on-site waste management concept is more sustainable in long term. Hence, such technologies shall be made mandatory for Rural and peri-urban areas in developing countries like India. Moreover, in country like India, the climatic conditions are more favourable for anaerobic digestion, which has a great energy potential. Hence, instead of merely copying waste water treatment techniques from other western countries, where climatic conditios are altogerther different, concepts as mentioned above shall be practice for sustainability.

CONCLUSIONS

From the overall Research and Review Work work carried out so far for ascertaining the sustainability of wastewater management systems in Upper Bhima Basin, it can be concluded that, for peri-urban and rural areas, on-site sanitation techiques which are dweller-oriented have proved to be more suitable rather than the centralized and costly systems of sanitation. For new development trends in Upper Bhima Basin, such as Development of Self-sustainable Townships catering to a population of 25000 to 1,00,000 souls, such techniques will be much more useful than the conventional waste water treatment plants that require huge capital, higher O&M cost as well as skilled supervision.

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