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CONTENTS

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Introduction

In continuation with the earlier issue of the Asian Journal focusing on water related matters in the South Asian region, the current issue focuses on the problems related to water supply, sanitation and wastewater treatment. According to the World Health Organisation (WHO), nearly 2.4 million persons (a third of the world's population) will not have access of improved sanitation even by 2015. A large proportion of those bereft of improved water supply and sanitation facilities live in the South Asian region. Although, part of Millennium Development Goals (MDGs), South Asia has still more than 50 percent of its population living without sanitation coverage. On the other hand, about 768 million persons globally are still not using improved sources of drinking water. In rural areas, 1.7 billion people continue to rely on public taps. Less than half of the world's population enjoy piped water supply. In South Asia, 9 percent of the population is still using unimproved water supplies along 28 percent of the population has piped water supply.

Given this situation, improved sanitation and water supply remain major goals to be attained. To meet the target for reaching piped water supply and improved sanitation to the large masses of the world population, there exist close connections between water supply, wastewater use and wastewater treatment. This issue of the journal discusses problems and solutions related to water supply, sanitation and wastewater.

Sunita Narain establishes these connections. The growing population, increasing urbanization and water resource scarcity calls attention to wastewater use. Therefore, there is a need to integrate management of water supply and sewage in cities. The article by Khairul Islam and Aftab Opel highlights the status of improved sanitation in South Asia. It also presents a way forward for the region and points out that there is need for faecal sludge management that include the services of pit emptying, transportation, disposal and treatment to keep toilets running as well as ensure that faecal matter does not harm water resources. It also highlights manual scavenging continues in the region due to lack of sludge treatment.

Dinesh Kumar and Niranjan Vedantam present an empirical analysis of households in the Indian state of Andhara Pradesh, establishing causal relations so far with some motivational factors to use improved sanitation. His argument also suggests that access to water play a significant role in adapting improved sanitation facilities in addition to income and other social factors. An account of manual scavenging, article by Dr. Bindeshwar Pathak stresses the importance of removing this practice in India. He has also highlighted the role of low cost sanitation in this process.

The Wold Bank's water and sanitation programme constitutes an important regional initiative. An article by Joseph Ravikumar, Rajiv Raman and Shubhra Jain of the programme, focuses on industrial and agricultural reuse of wastewater in India. The article also examines strategies of wastewater recycling and reuse and draws attention to the economic value of these strategies. As a following, Rajesh Doshi brings out the experience of the Vapi Waste & Effluent Management Co. Ltd. for the treatment of wastewater and industrial effluents. Dr. M. P. Sukumaran Nair has discussed the strategies for sustainable hydrocarbon processing, considering the fact that these industries are using the bulk of water resources. Finally, Dr. Y. K. Alagh has opened a debate on the National Water Framework Law by commenting on the earlier article published in the last issue of the Asian Journal by Prof. Phillipe Cullet. We hope this issue of the journal will make interesting and stimulating reading.

Acknowledgement is due to the authors for their valuable contributions in successfully bringing out the current issue of the Asian Journal.

B. G. Verghese
Guest Editor

The Water-Waste Connection

Sunita Narain*

The journey of excreta begins with humans, who generate it. The next stage is that it must be 'collected'. Usually, this is where the toilet comes in. Then, it must be disposed off, or conveyed away, and 'treated'/cleaned.

The collection of sewage depends on the system for excreta use in the country. Indian cities have various disposal 'systems' in place. One, houses have individual septic systems – soak pits and tanks that store the waste. Two, the waste of the house is disposed off in drains. These drains could be open or closed drains.

A 'system of excreta disposal', however, should not be confused with the type of 'toilet' people use. The toilet in the house or outside can be connected to a septic tank, or a drain which is open or closed and which is connected or unconnected to a sewage treatment plant.

What all this means is that people and cities are on what may be called a sanitation trajectory. At the lowest end are the people with no sanitation facility at all. Then there are those connected to the septic tank system. Next, there are those who have toilets but no connection to a drain. Their wastewater flows into open depressions, or open drains that reach either water bodies such as ponds or lakes or a river (if it flows by a city).

But all aspire to convert to the flush toilet system, the water closet or wc, which is connected to an underground sewage system. The wastewater flushed away from the wc is pumped to a sewage treatment plant, where the sewage is treated and then disposed off in the river so that it does not add to pollution.

How much of urban India is at the top of the sanitation trajectory? How much of urban India will get there and when? Equally important: what will happen to our waterbodies if and when all of urban India reaches the highest rung of the sewage-producing ladder? How much water will be used, how much waste will be generated and how will this waste be treated?

Even surveyors of data do not understand the difference between the 'toilet' or latrine system and the 'disposal' system. As a result, the few nationwide surveys that have estimated the number of households with access to 'sanitation' end up confusing the toilet type with the system of excreta disposal. The 2001 Census of India, for instance,

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includes information on the type of toilet available within the house. So, its data do not encompass how the waste collected in, say, a water closet (flush toilet), is disposed off.

This data, which formed the basis of nationwide knowledge on the access to toilets, showed that in the country as a whole, 64 per cent households did not have access to any kind of toilet or latrine. In urban India, 26 per cent had no access to latrines. The census also found that 46 per cent of urban Indians had water closets – but it did not clarify whether these flush toilets were connected to septic tanks, open drains or underground sewage systems.

The 2011 Census is likely to amend this anomaly to some extent. It has revised its definitions and so information about toilets and the systems of conveyance of the waste will be available. The nature of the data is thus sure to improve.

But it isn't as if there is a blank until the 2011 Census data appears. The National Family Health Survey (NFHS-3) of 2005-06 has data on the state of sanitation in the country. It used a kind of categorisation that has now been assimilated into and used for the 2011 Census. NFHS-3 differentiates between those who have toilets and those who do not. It differentiates between those whose sanitation facilities have improved and those whose haven't. It looks at the kind of toilet used and how that toilet is connected to the sewage system. This survey shows roughly half of urban India has flush/pour toilet latrines and only 18.8 per cent of these latrines are connected to a piped sewerage system. In fact, the bulk of urban India, which has access to toilets, is connected to septic tanks.

National Sample Survey Organisation (NSSO) data allow us to spot a decadal trend, albeit hazy, in India's toilet-sanitation trajectory. This national agency has data for its 54th Round (January to June 1998) on drinking water, sanitation and hygiene. For its 58th Round (2002) and 64th Round (July 2008-June 2009), it has data on housing conditions and amenities. The NSSO surveys are quite difficult to compare, simply because the definition of a toilet has changed over the years of data collection.

Thus, as of today, there is no standard way of checking whether Indians have access to toilets and of what kind, which would also provide a proper idea of the kind of disposal system being used. There must be a way to count better. How else will policy better its design?

It is also important to understand the internal excreta divide of each city. In the political economy of defecation, cities have huge inequity in the use of water; they also have huge inequity in the disposal of excreta. The most glaring is within slums or within unauthorised settlements. The NSSO's reports on the state of latrines in slums, shows much still needs to be done in these areas.

In May 2008, the Union ministry of urban development put together an urban sanitation policy and vision 2015, which said it would correct the presently existing situation wherein:

– One out of six urban Indians is forced to defecate in the open every day;

– 26-50 per cent urban households suffer inadequate access to sanitation facilities;

– Only 30 per cent of urban households have access to sewerage systems;

– 37 per cent of all wastewater generated is let out into the environment untreated.

The policy said untreated sewage caused 60 per cent of the water pollution in the country and this had to be addressed. It was because of this untreated sewage, pre-eminently, that water was polluted. The ministry proposed to address this situation through state and city level sanitation plans, to be financed through a variety of approaches. The policy says loftily that the objective is to "transform urban India into community-driven, totally sanitised, healthy and liveable cities and towns".

But for now, the myth that it is the poor that pollute waterways is busted. Poor people, though large in number, use less water and so discharge less sewage. It is this inequity that must be understood.

In the 71 cities Centre for Science and Environment (CSE) has surveyed, some 23 per cent officially live in slums in cities (2001 Census). The survey estimates waste discharge from slums based on water of the city says it supplies to these areas – at a generous 40 litres per person per day. It finds that a stark disparity appears – this quarter of the cities generates only 5 per cent of the cities' sewage.

This maths is central to the tragedy inherent in the sanitation trajectory the country is on. The poor, who suffer from lack of water and face dehumanising conditions for want of toilets, also contribute the least to water pollution. But it is they who suffer the burden of diseases that exposure to bad quality water brings about.

The sanitation trajectory has another aspect: if a quarter of a city's people (and more) generate just 5 per cent of its waste, what will happen as they move up the toilet-sewage ladder?

Even before sewage can be treated, it has to be transported. Cities need drains which officially connect each household through an extensive and intricate network of connected pipes to convey the discharge to sewage treatment plants. But most Indian cities are far from this picture-perfect scenario. Where drains exist (and they exist in only a few areas, in only a few cities), these are clogged or broken and need refurbishment. Thus, official sewage transport just does not happen. Instead, sewage generated from households makes its way into open drains, lakes or any other depression it can find in its journey.

The 71 cities CSE surveyed reflect the country's sewage story:

Roughly 26 per cent of these cities, 19 cities in the survey, had no provision at all for sewage collection;

In another 40 per cent of the cities, 29 cities, the provision exists but notionally: 80 per cent of these cities' sewage is not collected;

In the rest, the picture is uncertain. This set of cities claims it has a network to transport sewage but does not keep any record of how much is generated and how much is transported. Even big and seemingly all-connected cities have an underground problem: for instance, Bengaluru's sewage network extends only in the core city area. The matter of sewage transportation is literally a black hole.

It is true the sewage-connection picture is a dynamic one. But since it mostly changes for the worse, it is difficult to keep track.

Thus, Indian cities have a two-fold challenge, which makes keeping pace impossible:

There is a huge deficit in connectivity and repair. The connection backlog is immense. Making sewage systems where buildings and all other constructions exist is a nightmare;

Cities are expanding, growing on the fringe; here the network does not even exist. The dis-connection only grows. In this situation, sewage spills everywhere.

Sanitation engineers believe that the network of drains – consisting of small auxiliary drains, which collect sewage from individual households, and main trunk drains which collect from these auxiliary drains and transport it to sewage treatment plants (STPs) for treatment – is like their underground treasure. The problem is that this treasure is mostly either lost or missing.

Laying the sewage network is one part of the story. If the network is underground, in most cases it needs electricity to pump the sewage to the disposal point. The pumping grid is a sign of a city's prosperity. Patna, for instance, has 18 sewage pumping stations; Kanpur has 13, while Chennai has the dubious distinction of possessing the highest number of pumping stations, about 196. These pumping stations need energy, electricity to run pumps, just to transport the waste. If they break down, which is often, waste is not moved, even if sewers exist.

There is also inequity in the reach of the sewerage network. In large cities like Mumbai or Delhi, while an underground sewage system exists, it does so only in certain parts: the affluent and/or older parts of the city. In such cities, where most people live in unauthorised colonies, slums or even in newer developments, underground sewerage does not exist. The excreta of these areas flows into open drains and often mixes with the collected and even treated sewage of the 'connected' areas. The end result is the same: pollution.

But the task is made even more difficult, because what exists itself requires funds for maintenance and refurbishment. This urban asset has suffered from neglect over the years and, today, most cities find that even where the drains exist, they are clogged and non-functional. Cities encounter a game: as they set out to build a new sewerage network, the old one collapses or needs more money for repair. Chasing pipes, this game is called.

What makes this pipe-game a losing battle is the fact that India's cities are growing faster than they can count? Even as the city sets an objective to build for the present city and repair the existing network, there is growth outside the sewage ring. New colonies spring up, not connected to the sewerage system. The chase-game begins. The chase-game is not just never-ending. Sometimes, it never even starts.

There is a long way to go to build these systems. In Allahabad, underground drainage exists in certain areas but is old and desperate for repair. Situation is the same in Aurangabad, Dhanbad as well as in Solapur. Other cities, like Cuttack, do not even have the semblance, or pretence, of this system.

Even metros such as Bengaluru do not have a requisite sewage system. The city is struggling to repair its existing 3,610 km-long system, which reaches most of the old Bengaluru. But the city realises it also needs to build more than what it has presently – an additional 4,000 km – to be able to collect the waste of its current inhabitants. If the entire system is not built, the sewage not intercepted and transported will make its way into waterbodies and rivers. The effort made to collect and even treat the waste of 'some', of those connected, will not yield any benefit.

In Delhi, again, the sewage network extends over roughly half the area and what exists needs refurbishment. This 'half' system is the reason the capital city's river, Yamuna, has remained a sewage canal, in spite of huge investments to clean it.

Then, there are cities that can claim their sewage systems cover large parts. Such cities, too, are now fighting a losing battle to maintain the old and to build new systems in newer areas. The problem here is that such cities, in the process of growing envelop large parts of the non-municipal areas, which do not have these systems. For instance, Gurgaon, the fast-growing metropolis at the border of Delhi, boasts of a sewage system but only in its older, poorer parts. The newer areas, more rich and powerful, are ironically left out of the drainage loop.

In any case, official estimates are way off the mark in these matters. For instance, in Yamunanagar, the Public Health and Engineering Department (PHED) asserts 55 per cent of the city population is covered by sewer systems, but both Yamunanagar and its twin city, Jagadhri, together have only 8,733 sewer connections, driving home the fact that more than 75 per cent of the cities' population lacks any proper sewage collection system. So, the bulk of Yamunanagar's waste goes untapped.

More seriously, although no new connections for sewage have been given in the past some years, the volume of wastewater generated has increased, with increase in population and water use. The twin cities' officials also accept that even though sewers have been constructed, many houses are not connected to the outfall. The local PHED says people are not willing to take up sewer connections because of the initial cost charged to each household. Of course, 'illegal' houses cannot be given 'legal' connections.

Three cities boast of working systems and substantial coverage: Surat, Pune and Chennai. In Pune and Chennai, such full coverage has not led to full clean-up. Their rivers remain extremely polluted and are getting worse each day, even after pots of money have been spent on clean-up operations. In Chennai, the local government has spent crores on cleaning its rivers, the Cooum and the Adyar: the maximum amount spent on any one river after the Ganga and the Yamuna. Pune, too, is struggling to clean up the Mula and the Mutha rivers.

Only in Surat is the news better. A little better. The municipality treats most of its sewage, which it disposes off in a nearby creek, not in the Tapi River. The city now wants to 'beautify' its riverfront. But the bad news is the chemical oxygen demand in the river is increasing, alarmingly. This signals a new challenge: pollution not from sewage, but industry. Also, as the city is growing new areas are unconnected to the network. Coverage is slipping.

Pipes and pumps to transport sewage are parts of the process. The conveyance system needs to be connected to a treatment facility, to clean the sewage before its disposal into a waterbody or on land. The only assessment of sewage generation and treatment capacity comes from the Central Pollution Control Board (CPCB). In 2006, it estimated that India had the installed capacity to treat roughly 21 per cent of the sewage it was generating. In 2009, the situation marginally improved. The country had the installed capacity to treat 30 per cent of the sewage. But the CPCB's calculations hide an enormous skew: the bulk of sewage treatment capacity exists in the metropolitan cities. With 40 per cent of wastewater generation, these cities have some 70 per cent of the installed capacity. More importantly, just two cities – Delhi and Mumbai – have some 40 per cent of the country's installed capacity. In other words, although these two cities generate some 17 per cent of all the sewage in the country, they hog the bulk of the country's sewage treatment infrastructure.

The bulk of treatment facilities also exist on the river Ganga, simply because the Ganga Action Plan to 'clean' the river was a frontrunner in building sewage facilities. According to the CPCB, cities (big and small) dispose directly into the Ganga and into its tributaries some 30 per cent of India's urban sewage. However, these cities also have more than 40 per cent of the country's installed treatment capacity. But even with all this done, the river is still polluted! For sewage to be treated, it has to be conveyed to the plant. But most cities do not have sewage drains to intercept waste or convey it to the plants. In this situation, the plant is built but there is no sewage to treat.

According to CPCB, though the installed capacity in 2006 was enough to treat 21 per cent of all waste generated, actual treatment was only 15 per cent. Its 2009 report does not estimate the unutilised capacity, but it's fair to assume that the gap still exists.

In India today, the survey shows, there is a complete disconnect between water supply and sewage management. The result is pollution.

Toilet for All is Not the End of the Problem: Countries in South Asia Need to Think Beyond Toilet Construction

Md Khairul Islam* and Aftab Opel**

INTRODUCTION

Despite enormous health and economic benefits associated with increased access to improved sanitation (Chambers and Medeazza, 2013; Brown, et al., 2013; WSP, 2011a; WSP 2011b), it is really unfortunate that most countries in the South Asian region are still off-track to meet the millennium development sanitation goal (UN 2013). This eventually leads to the result that whatever attention at the country level is paid to sanitation is only narrowly focused on decreasing open defecation, increasing the coverage of improved sanitation and bringing the poor households under safe sanitation coverage.

However, sanitation is not just using and having access to improved toilets. Pits and safety tanks get full after a certain period, and they have to be emptied to keep the toilets functional. Emptied sludge has to be treated and disposed properly so that it does not harm public health (Franceys, et al., 1992; Eales, 2005). Otherwise, it remains as 'disease time bomb' and often explodes resulting in waterborne disease outbreaks (Carter, 2013). In the absence of proper emptying, transportation, dumping and treatment facilities from the sludge, potentials remain as high as using unsafe sanitation or practicing open defecation for untreated excreta directly going into the environment and risking public health (Opel, 2012; Carter, 2013).

This risk is much high in the urban areas due to high urban population density and usually close proximity between disposal sites and residential areas in the cities and towns. Since the pace of urbanisation is high in the region, the management of faecal sludge has emerged as a major public health challenge in the urban areas of countries in South Asia. The biggest sufferer of the current state of unimproved management of faecal sludge in this region is mainly the low-income people who live in the high risk environments with limited or no access to essential services.

Countries in South Asia, therefore, need to take into account the fact that without proper management of faecal sludge, the investments countries keep making in sanitation will not produce its fullest benefits. This paper provides a brief situation analysis and highlights that the issue of faecal sludge management needs to be in the agenda and deserves urgent attention at the policy and programme levels.

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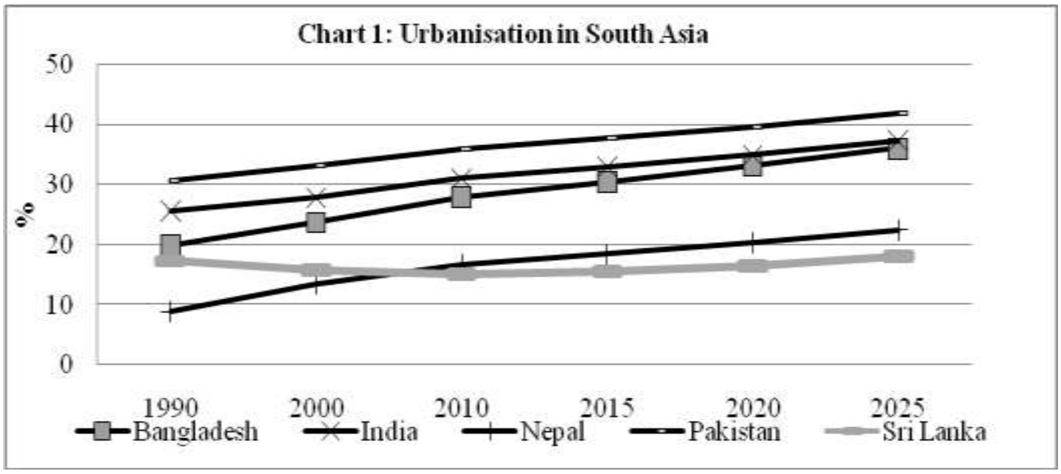
URBANISATION AND URBAN POVERTY IN SOUTH ASIA

Like the other parts of the world, South Asia is also becoming urbanised very rapidly (See Chart 1). Presently, of the world's ten fastest growing cities, four are in Bangladesh and India (ADB, 2013). World Urbanisation Prospects (revised, 2011 edition) suggests that countries in South Asia experienced 3.06% annual urban population growth rate during 2010-2015. Over one-third of the population in these countries will be living in cities and towns by 2025 and projections suggest that if the current growth rate continues, almost half of the total South Asian population will be living in urban areas by 2050 (ADB, 2013).



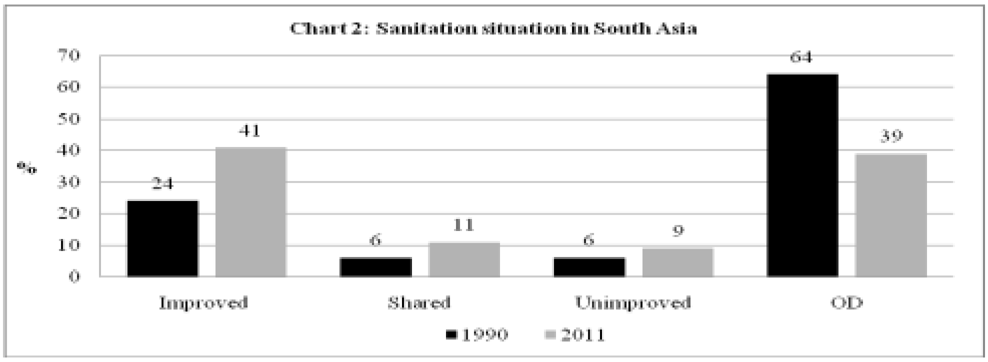
Source: World Urbanisation Prospects, UNDESA (revised, 2011 edition)

However, increased urbanisation does not necessarily mean that people are becoming richer and there have been improvements in the overall well-being of the people. In South Asia particularly, although overall poverty situation has taken a declining trend (UN 2012); unfortunately, urban poverty is still rampant in the region. Presently, 35% of the urban population in South Asian countries, or 190.7 million people in India, Bangladesh, Nepal and Sri Lanka live in slums and squatter settlements in the cities and towns, most of whom lack adequate access to basic services which, in turn, exacerbate poverty (ADB, 2013).

SANITATION IN SOUTH ASIA

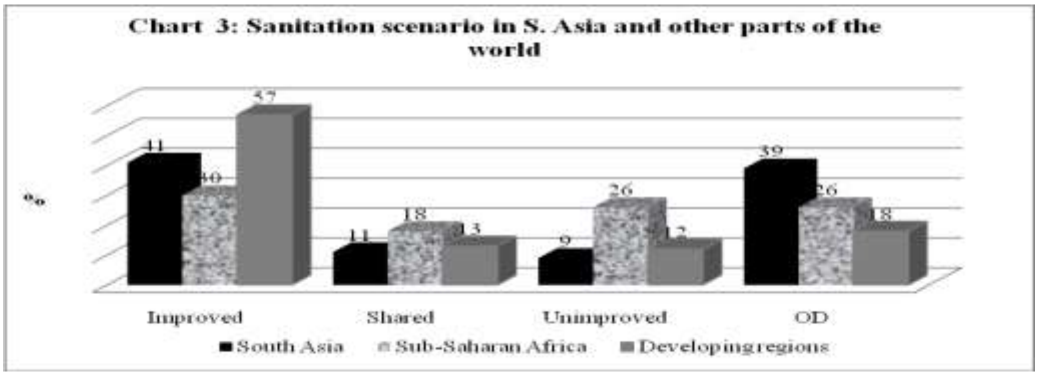
South Asian countries have made some good progress over the past several years in reducing open defecation and increasing use of improved sanitation. Open defecation has reduced at an average rate of 1.19% annually which has come down from 64% in 1990 to 39% in 2011. Use of improved sanitation has increased by 17% during the same period; however, annual rate of progress is rather slow i.e. 0.8%. Some 61% people in South Asia now use some kind of toilet which is an increase by 0.95% annually since 1990 (See Chart 2) (UN 2013).

Open defecation is still a major problem for countries like India and Nepal where 49.6% and 43.5% people respectively defecate in the open. In Pakistan too, 23.2% people do not have access to any kind of toilet. They defecate in the open. Only country in South Asia where everyone has access to a toilet is Maldives, although some 2% people in this country do not have an improved toilet. Sri Lanka is the other country in the region which has very low rate of open defecation (0.06%) although 8.9% people in this country use unimproved toilet (UN 2013).



Source: WHO/ UNICEF Joint Monitoring Programme for Water Supply and Sanitation

Progress in sanitation coverage in South Asia is not as good as the other parts of the world. Although use of shared toilets and unimproved toilets is higher in the sub-Saharan Africa and the developing region, the rate of open defecation is much less in these two regions compared to South Asia (See Chart 3). Greater effort is, therefore, needed in the South Asian region to improve the overall sanitation situation which has an adverse effect on most of the millennium development goals (UN 2013).

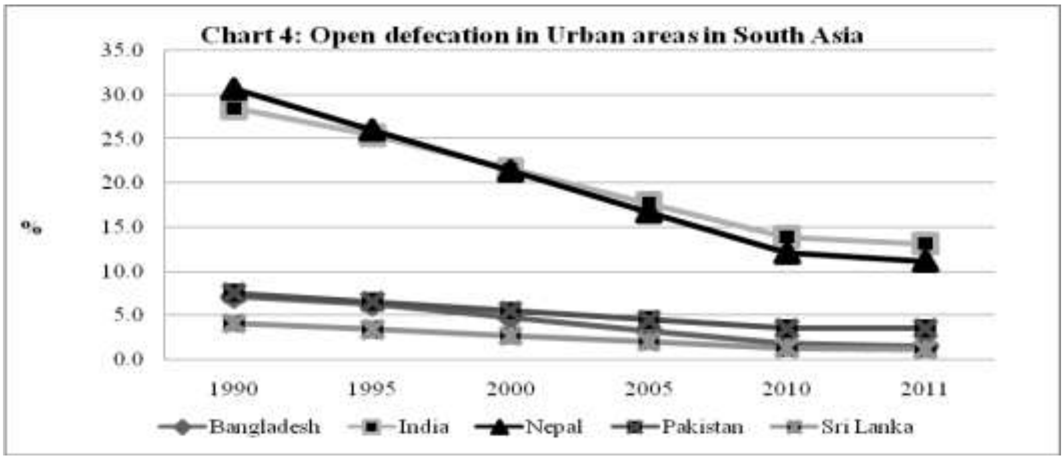


Source: WHO/ UNICEF Joint Monitoring Programme for Water Supply and Sanitation

URBAN SANITATION IN SOUTH ASIA

Urban sanitation in South Asia is predominantly on-site because it is cheaper than the sewerage system (Franceys, et al., 1992; Trémolet, et al., 2010), is affordable by the low-income people (Cairncross et al., 2010) and can be built at household level without much involvement of the authorities (Opel, 2013). Inspite of this, a huge part of urban population in South Asia still defecates in the open. This is strongly correlated to urban poverty, since poverty has a direct impact on sanitation practice.

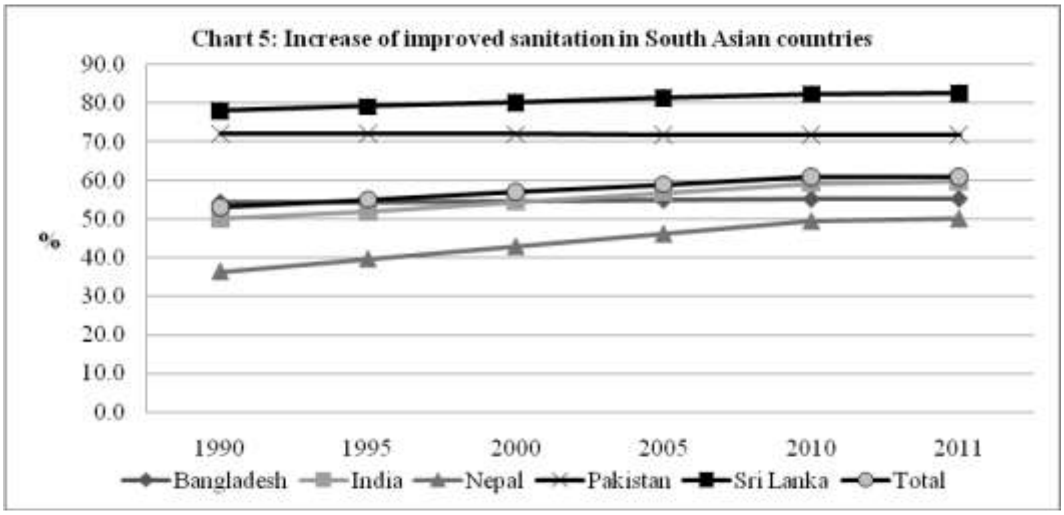
A significant percentage of the people living in the slums and squatter settlements in different countries which is 35% of the total urban population in South Asia enjoy less access to improved sanitation facilities and services. As presented in the graph below (See Chart 4), although there is a sharp decline over the past few years, still two out of five South Asian countries had more than 10% of the urban population practice open defecation in 2011 (India: 13.15 and Nepal: 11.1%). A country like Sri Lanka, which is considered to be and the most of successful countries in the region to deal with sanitation, still has over 1% of its urban population defecate in the open.



Source: WHO/ UNICEF Joint Monitoring Programme for Water Supply and Sanitation

Countries like India and Pakistan have higher percentage of urban population connected to sewerage lines as compared to Bangladesh, Nepal and Sri Lanka. However, most money spent in all these countries on urban sanitation, it aimed at seeking engineering solutions and taking up big budget projects to bring more people into the sewerage coverage. As a result, none the countries in the region have made any remarkable progress over the past decades in bringing people into improved sanitation coverage, as shown in Chart 5 below.

It might be surprising to know that despite so much of effort two countries in the region, Bangladesh and Pakistan have seen a decline in the coverage of improved sanitation in the urban areas over the past two decades. During the same period, five South Asian countries together got only 8% increase (from 53% in 1990 to 61% in 2011) in the coverage of improved sanitation in the urban areas which is mainly driven by Nepal (13.8%) and India (9.6%). Sri Lanka achieved 4.6% increase over a period of 21 years (See Chat 5).



Source: WHO/ UNICEF Joint Monitoring Programme for Water Supply and Sanitation

One of the major reasons for this rather slow improvement is that urban development has not been happening commensurate to population and physical growth of the cities. The other reason is that most money is invested in maintaining the existing sewerage infrastructure or bringing the urban richer areas, which are usually low density areas, into the sewerage coverage (Opel and Islam, 2013; WSP, 2012). As a result, people belonging to the poorer economic quintile, who usually live in the low-income slums and squatter settlements, the home of incoming migrants in the cities, remain excluded from improved services. This has an obvious impact on overall services level.

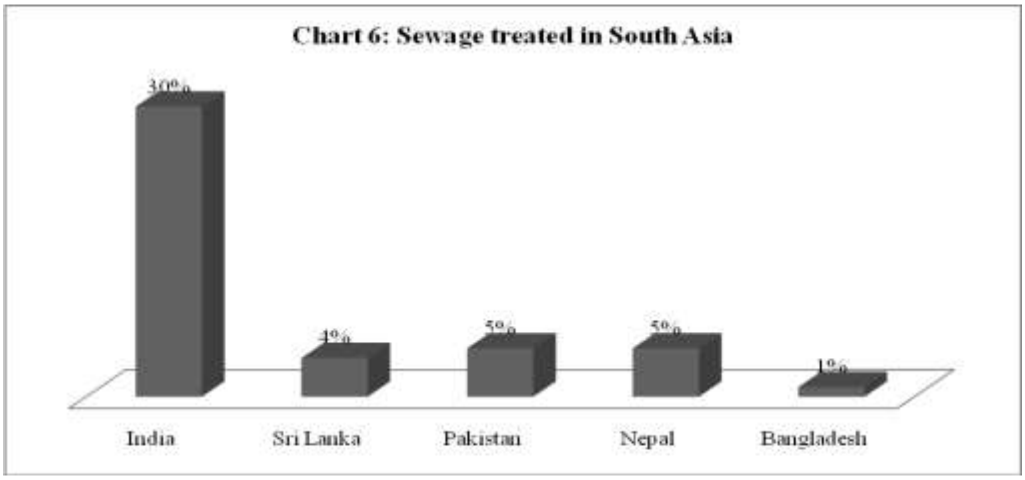
FAECAL SLUDGE MANAGEMENT: AN EMERGING CHALLENGE

Added to the existing challenge of bringing people under the service coverage keeping toilets running by emptying pits when they are full and treating sludge before final disposal emerged even as a bigger challenge for the cities and towns in South Asia. Decreasing trend of open defecation that has been achieved over the past decades and small coverage of sewerage systems means that there has been a prolific growth on on-site sanitation in the urban areas in South Asia which demands this service.

However, other than India, no country in the region has any significant faecal sludge management and sewage treatment capacity and capability (see Chart 6). As a result, most sludge goes into the environment untreated with full potential to harm public health; thus, shattering the gains achieved through increased toilet coverage.

India: Out of so many cities and towns in India, only a few have any functional faecal sludge management system and treatment plants that can effectively treat sewage sludge and wastewater before they are discharged into the environment. A recent study suggested that currently, only about 30% of the sewage sludge goes to the treatment plants. The rest, although mostly collected by mechanical emptier goes directly to the environment which someway or the other contaminate surface water as well as groundwater (CSE, 2011).

Pakistan: A recent study estimated that almost half of the country is under the coverage of sewage collection of which urban areas account for 30 per cent. Of this total coverage, only 10 per cent of sewerage was being effectively treated. This means that only about 5 per cent of the urban sewerage is being effectively treated. Not all cities and towns have treatment facilities and many of the existing treatment plants do not work (WSP, 2012). On the other hand, there is no functional system of pit emptying, transportation, treatment and disposal for the areas not covered by sewerage lines. As a result, sludge from the huge number of pits and safety tanks goes into the open environment without prior treatment.



Source: compiled from CSE, 2011; WSP, 2012; HPCIDBC, 2011, AECOM, et al. 2010; Opel, 2012

Nepal: The scenario is no different in Nepal. There are a few treatment plants set up by the public sector in different towns but hardly any of them works for various technical and management problems. As a result, only less than 5% of the total sludge generated is treated before it is finally disposed into the rivers. There are a number of private companies which provide pit emptying and transportation services. However, in the absence of any functional treatment facilities, these companies do not have any option other than disposing the collected sludge into open without prior treatment (HPCIDBC, 2011). Illegal connection of sewerage to storm water drains is also common in many parts of Nepal.

Sri Lanka: Highly successful country in the region to deal with the sanitation problem has seen widespread ignorance to the management of faecal sludge. Most of its large cities such as Colombo, Galle, Jaffna and Kanday do not have the requisite treatment and disposal facilities of sewerage sludge (Bandara, 2003). A few small-scale treatment plants established and run by the public and private sector are hardly functional due to technical and management problems (Sudasinghe, et al., 2011).As a result, only less than 4 per cent of sewage is treated before final disposal (AECOM, et al. 2010)

Bangladesh: The situation is worst in Bangladesh compared to any other country in the South Asian region. There is only one sewerage treatment plant in Dhaka which serves about 20 per cent of the city. Most part of the rest of the city is illegally connected to the storm drainage system which takes away sewage to the river that surrounds the city. No other cities or towns throughout the country have any treatment facilities. Excluding a very few examples of using mechanical devices, in almost all cases, pits are emptied manually and sludge is disposed in the open environment untreated. A recent estimate suggests that only less than1% of the total sludge generated throughout the country is treated before disposal (Opel, 2012).

IMPLICATIONS AND WAYS FORWARD

South Asian countries face dual challenges with regard to sanitation; first, eradicate open defecation and bring people into safe sanitation coverage, and, second, effective management of sludge to keep the improved toilets running and prevent faecal-oral disease transmission. Both are equally harmful for public health. It's unfortunate but a matter of great surprise that the issue of faecal sludge management remains almost unattended throughout the region. As a result, full benefits of increased toilet coverage remain unattained.

Economic impacts of inadequate sanitation have been systematically studied and measured for three countries in the region. The total economic impacts of inadequate sanitation in Bangladesh amount to a loss of US$ 4.2 billion each year which is equivalent to 6.3 percent of GDP of Bangladesh in 2007 (WSP 2011a). In India, this loss stands at US$ 53.8 billion which was equivalent to 6.4 percent of India's GDP in 2006 (WSP 2012a) and in Pakistan, the loss is US$ 5.7 billion which is equivalent to 3.94 percent of GDP in Pakistan in 2006 (WSP 2012). Similar measures are not available for Nepal and Sri Lanka, but since the situation is no different in these two countries, it can be assumed that they also incur similar amount of losses for inadequate sanitation. While the economic impact of poor sanitation is so huge for the countries, it's a matter of great surprise that the countries still emphasise toilet-based sanitation development and ignore proper management of faecal sludge.

Faecal sludge management is considered to be one of the principal means of breaking the faecal-oral disease transmission cycle (Howard, 2002; Shordt, 2006), which is highly associated with the reduction of child mortality (Esrey et al., 1991) and is a powerful measure to control the transmission of helminth infections (Esray, 1996). However, sanitation policies of the countries in the region seriously overlook the importance of sludge management as an important component of sanitation systems.

The reason behind widespread ignorance of the issue of faecal sludge management is that a narrow definition of sanitation dominates policy and programmes. Sanitation is often perceived as having people using improved toilets and not defecating in the open, but sanitation is not just limited to use of toilets. Sanitation has a greater meaning which refers to a whole system which effectively ensures the management of excreta (WSSCC and WHO, 2005) so that public health is protected from excreta related health hazards and diseases. Unfortunately, the focus of the governments in the region remains toilet based sanitation development.

On the other hand, a critical review suggests that significant reduction in open defecation and rise of unimproved toilets that the South Asian countries have seen over the past decades is mainly due to an increase of awareness among the citizens who installed whatever types of toilets they can afford on their own or through some assistance from the non-governmental organisations. The role of the governments is almost negligible in terms of financial contribution or implementing programmes to build household level or community level toilets. As mentioned earlier, most of the government money goes to the big infrastructure projects on developing new sewerage lines or on maintaining the existing ones which mostly benefit the richer segments of the societies.

It is extremely important for the respective governments to understand that urban sanitation in South Asia is predominantly on-site, which means that there is a need for faecal sludge management that includes the services of pit emptying, transportation, disposal and treatment to keep the toilets running as well as to ensure that faecal matters do not harm water resources which cannot be done by the households and communities alone. Presently, although there are examples of private sector interventions in all these countries to provide this service, in most cases they do not run profitably and are not very sustainable for various reasons (Opel and Bashar, 2013). As a result, despite enormous demand of improved services, manual empting dominates the markets. On the other hand, in whatever manner emptying and transportation is done there is no benefit if the sludge is not treated before final disposal. It is, therefore, urgent that countries take the issue seriously, experiment different low-cost and affordable treatment technologies, share their experiences and knowledge with each other and ensure that the investment each country makes in sanitation produces fullest benefits to the citizens.

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Determinants and Motivational Factors for Adoption of Improved Latrines: Findings of a Study from Rural Andhra Pradesh, India

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INTRODUCTION

Worldwide, few large scale sanitation programmes in developing countries have succeeded in achieving the desired outcomes. Still, in many parts of the developing world, communities make their own investments in private sanitation infrastructure, without any subsidy (Jenkins and Scott, 2007). Increasingly, marketing techniques are advocated to generate demand for household sanitation as a way to leverage both individual and community level resources to close the sanitation gap (Cairncross, 2004). Understanding constraints to adoption is the starting point in any effort to boost the demand for improved sanitation (Jenkins and Scott, 2007). Constraints vary in their effect on sanitation decisions. Permanent constraints are likely to act at a very early stage of decision making, whereas the temporary ones would come in the way at the later stage of making the final choice (Jenkins, 1999).

The Total Sanitation Campaign (TSC), launched in 1999, was a major institutional reform in India's sanitation sub-sector.[1] It marked a paradigm shift from a centralized supply-driven Government schemes to a community-based "demand-driven" programme for improving the living environment in rural areas (WSP/GOI, 2008). The programme therefore provides very little subsidies for actual physical infrastructure, and embarks on social marketing techniques, such as Information, Education and Communication (IEC) to stimulate household demand for sanitation. Therefore, understanding the constraints as well as the determinants and motivating factors for adoption of improved sanitation practices is the key to evolving strategies for successful implementation of sanitation programmes in rural areas. The state of Andhra Pradesh has a total population of around 8.47 crore people.[2] In 2001, nearly seventy-three percent

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1. The total Sanitation Campaign was rechristened as Nirmal Bharat Abhiyan (NBA) by the Ministry of Rural Development, Government of India in April 2012, with major amendments in the provisions under the scheme, including the extent of subsidy and target beneficiaries.
2. Provisional figures from the Census of India-2011

of the population lived in rural areas. As per most recent estimates, the state has nearly 72,000 rural habitations comprising 137 lac households, and 4162 municipal wards with 41.7 lac households. The state, which has three distinct regions, also has diverse climates. Coastal Andhra is a flood-prone region, while Rayalaseema is a dry region. Telangana, also being upland in the Deccan plateau, mostly remains as a rain shadow region. Coastal and Rayalaseema regions are exposed to modernization as they were under the British rule. Telangana region has also caught up with modernization during the past 50-60 years.

Major claims are made about the success in implementing water and sanitation programmes in the state. For instance, 31.5% of rural households and 67.9% of urban households in the state (Source: Census 2011) were reported to have access to drinking water source within the premises. This is against 22.8% rural households and 57.2% urban households having access to drinking water sources within the premises in 2001. Further, nearly 32.2% of rural households and 86.1% of urban households in the state were reported to have access to latrines as per 2011 Census. This is against, 18.2% and 78.1% for rural and urban households, respectively having similar facilities in 2001 (Source: Census 2001). In spite of such impressive physical target achievements, the hinterlands and the slums in the urban areas suffer from improper hygiene conditions and lack of latrines for a variety of reasons. As a result, outbreak of waterborne diseases and infections are a common phenomenon in these areas. The key to understanding this contradiction lies in knowing the real determinants of adoption and the motivating factors.

THE STUDY

A study was carried out in rural Andhra Pradesh covering 10 districts to: (1) assess the actual extent of adoption of improved toilets by the rural households; (2) analyze the determinants of adoption, and the motivational factors; (3) analyse the adoption constraints; and (4) evolve strategies for promotion of improved sanitation in rural areas of Andhra Pradesh3. The survey covered a total of 2700 households which were reported to have adopted improved toilets (as per the Total Sanitation Campaign list) and 900 households which were reported to be non-adopters of individual household latrines. However, the results showed that actually only 2446 households had actually built toilets. The findings of the study, with regard to determinants of adoption of improved toilets and the motivational factors for adoption, are presented in this article. The article also discusses the strategies for promoting improved sanitation in rural areas of the state, which are based on the overall findings from the study.

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3. The study was commissioned by UNICEF, Hyderabad. However, the views expressed in this article are solely of the authors and do not represent that of the UNICEF.

DETERMINANTS OF ADOPTION OF IMPROVED TOILETS BY RURAL HOUSEHOLDS

A multivariate analysis using a 'logit model' was run to identify under what conditions a rural household is most likely to adopt an improved toilet in the given circumstance. The model used the following variables to begin with, for the analysis: (1) the per capita annual income of the household (HH); (2) caste profile of the family (whether belonging to the forward caste); (3) number of literate adults in the family against the total family size; (4) number of literate female adults in the family; and (5) number of school going children. These variables could predict the adoption of toilets by individual households with 74.9 per cent probability. However, the effect of two independent variables viz., literate women in the family and number/percentage of school-going children on toilet adoption was found to be negative as per the model predictions, when both were considered in the model along with the other three variables. But when only four variables were considered in the model (after excluding the variable, 'number of school-going children'), the effect of all of them, including 'literacy of adult women', was found to be positive.

Subsequently, the model was run with the variable, 'number of children below the age of five' in place of 'number of school-going children', along with the other variables used in the previous logit model. The results from the logit model are presented in Table 1. The effect on toilet adoption was found to be positive for all the five variables. Here again all these variables together could explain adoption of Individual Household Latrines (IHHL) to an extent of 74.9 per cent. The effect of income was the lowest, with every 10,000 rupee increase in per capita income changing the probability of finding an adopter household by nearly 75 per cent (with a beta coefficient of 7.5 X 10^-5); whereas being in a forward caste family could increase the chance of the household having a toilet by 62 per cent as compared to a backward caste family (beta coefficient is 0.62). Presence of a literate woman in the family could increase the chances of having a toilet by nearly 25 per cent. Whereas an increase in percentage of literate adults in the family by around 20 (increase in literate adults by one person) would increase the chances of adoption of toilets by around 8 per cent.

The data used in the logit model (Sample Size= 2,446) covered 10 districts, comprising all the three regions of Andhra Pradesh, viz., Rayalaseema, Coastal Andhra and Telangana and all the nine agro-climatic regions in the State. While we had chosen 2700 households for adopter category at the time of starting the survey, many of them turned out to be non-adopters after field visit and hence were subsequently removed from the sample. Therefore, the adopters here are those who actually built individual household latrines, and not those reported by the TSC. The data considered for running the logit model also included 900 non-adopters from the 10 districts, with 90 HHs from each district.

Table 1: Results from Logit Model on Adoption Determinants

Independent Variables	Beta Coefficient	S. Error	Wald	Df	Level of Significance	R	Exp (B)
Per Capita Income (Rs)	7.5E-05	1.49E-05	25.55	1	0.000	0.0924	1.00
Caste (1,0)	0.6262	.1624	15.0465	1	0.0001	0.0688	187
Family Literacy (%)	0.0041	.0019	4.9114	1	0.0267	0.0326	1.004
Children Below 5 (#)	0.0347	.0762	0.2079	1	0.0484	.0000	1.035
Female Literacy (1,0)	0.2400	.1250	3.6875	1	0.0548	0.0247	1.2712
Constant	0.0996	0.1288	0.4474	1	0.5036		

The results show that the household socio-economic dynamic could significantly influence the adoption decision of the family with regards to toilets. Those families which are socio-economically backward (in terms of caste, income and literacy) would require greater incentive to adopt toilets as compared to those who are literate, economically well off and socially backward.

A far more straightforward analysis was carried out using five distinct socio-economic variables, in which the average values of these variables were compared for adopter and non-adopter households. The variables used are: per capita family income; no. of children below the age of five; no. of literate women in the family; percentage population in general category; and average no. of literate adults in the family. The results are presented in Table 2.

Table 2: Comparison of Socio-economic Attributes of Adopter and Non-Adopter Households

Name of the District	No. of children below the age of five		% Population in General Category		No. of Literate Women in the Household		No. of Literate Adults in the Family		Annual Family Income (Rs)	
	Adopter	Non-adopter	Adopter	Non-adopter	Adopter	Non-adopter	Adopter	Non-adopter	Adopter	Non-adopter
Medak	0.46	0.5	21.1	14.1	0.8	0.7	3.8	3	29544	25685
Nellore	0.21	0.19	24.1	7.1	0.46	0.32	1.72	1.41	22627	19571
Nizamabad	0.44	0.33	0.0	0.0	0.92	0.28	3.09	1.6	26275	16476
Warangal	0.18	0.28	20.9	7.6	0.81	0.7	2.67	1.12	22083	19489
Visakhapatnam	0.15	0.22	18.1	14.0	0.64	0.59	2.1	2.42	21862	15161
Srikakulam	0.27	0.36	9.6	1.1	0.54	0.46	2.02	2.14	23958	19950
Anantapur	0.33	0.45	28.5	14.6	0.82	0.69	2.98	2.54	34939	29579
Mehbhubnagar	0.36	0.28	20.8	6.7	0.94	0.24	3.21	2.39	35055	25622
Krishna	0.05	0.01	11.1	13.4	1.16	1.23	4.08	4.17	23744	24756
West Godavari	0.13	0.1	0.7	2.8	0.81	0.68	2.5	2.1	18801	16597
Overall	0.25	0.27	15.7	8.3	0.8	0.6	2.8	2.3	25520	21323

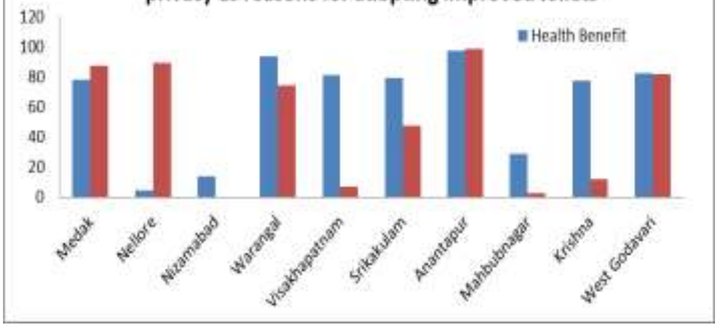
Source: Authors' own analysis based on primary data from survey of adopters and non-adopters

It shows that the values of all the five variables are consistently higher for adopter households as compared to the non-adopter households across the districts. The values are consistently higher for the adopters, when the state-wide data are compared.

MOTIVATION FOR ADOPTING OF IMPROVED TOILETS

Health benefits, time saving, improvement in living standards, accessibility and self-esteem and privacy are generally the most important reasons for adopting improved latrines. But, village situations are often complex, and the motivating factors can change according to the socio-cultural environment and overall socio-economic profile of the region, apart from the socio-economic condition of the household in question. In very poor localities, the general feeling of self-esteem etc. would be low. In comparatively rich localities, even those who are economically poor might invest in improving their living standards. A total of eight factors were identified as the motivating factors for the households to adopt improved latrines.

Figure 1: Percentage HHs who consider health benefits & privacy as reasons for adopting improved toilets



The significance of each one of these factors in terms of number of households which recognize them varies across districts. The results are presented in Table 3. Its graphical representation is given in Figure 1. The table shows that the 'health benefit' is a motivating factor for largest proportion of the households across the sample districts to opt for improved latrines. However, the proportion of the people who consider this as a factor varies across the districts: from as low as 4.3% for Nellore to as high as 97.4 % for Warangal. 'Privacy and self-esteem' appear to be another motivating factor for the second highest proportion of households to go for toilets. But, the proportion is as low as 0 per cent for Nellore to the highest of 98.7 per cent for Anantapur. This is followed by 'accessibility', and 'time saving' which 38% and 30%, respectively of the households consider as reasons.

FINDINGS

The health benefits (66%) and privacy & self-esteem (53%) appear to be the factors maximum people consider as motivating for adopting an improved toilet. The other factors are accessibility (38%), time saving (33%), social status (30%) and better living standard (17%). On the other hand, there are five important socio-economic parameters which drive adoption of improved toilets at the HH level. They are the economic condition of the family, overall adult literacy, presence of literate (adult) females in the family, caste and number of small children below the age of five. These five factors create conditions for households to get motivated for adopting improved sanitation methods, by increasing the benefits.

Table 3: Factors Driving Households to Adopt Individual Latrines

District	Percentage Households Reported to Reasons							
	Social status	**Health benefits**	**Privacy and Self Esteem**	**Accessi-bility**	**Lifestyle Improve-ment**	**Time Saving**	**New Social Norm**	**Availa-bility of Financi al Aid**
Medak	0.40	78.1	87.8	2.2		1.5		
Nellore		4.3	89.5	0.8	4.7			0.8
Nizamabad	7.10	14.1				7.7		
Warangal	57.2	93.5	74.6	66.7	34.8	76.1	2.5	10.4
Visakhapatnam	16.2	81.5	7.2	4.2	13.6	11.3	2.3	0.4
Srikakulam	7.20	79.2	47.5	26.4	5.7	17.4	1.9	
Anantapur	31.6	97.4	98.7	44.7	36.4	66.7	18.4	48.7
Mehbhubnagar	80.3	29.0	2.70	56.8	2.2	4.4	3.8	0.5
Krishna	86.3	77.41	11.9	96.7	12.2	84.1	1.9	0.7
West Godavari	20.2	82.4	81.6	77.5	54.7	49.4	6.7	
Overall	30	66	53	38	17	33	4	6

For instance, the benefits are high when: (1) the earning potential of the household is high and the members do not have time to waste, on going out in the open for defecation; (2) the family has children, particularly those in the age group of 0-5, which makes it vulnerable to negative health consequences of poor sanitation; and (3) the overall educational status of the family is good, which makes toilet a necessity for maintaining a dignified lifestyle. But, certain benefits are better recognized when the members of the household, especially women, have education. Education helps the family recognize the health hazards of practicing open defecation. It also helps them appreciate the value of time and indirect economic gains from time saving.

Every 10,000 rupee increase in per capita income increases the probability of a household adopting a toilet by nearly 75%; whereas being in a forward caste family could increase the chance by 62% as compared to a backward caste family. Presence of a literate woman in the family could increase the chances of having a toilet by nearly 25%. On the other hand, an increase in the percentage of literate adults in the family by around 20 would increase the chances by around 8 per cent.

PRACTICAL INTERVENTIONS FOR BOOSTING ADOPTION

Provision of Subsidized, High Quality Toilets with Proper Targeting and Monitoring

There is a strong need to use economic principles in allocating resources for promoting improved sanitation at the household level. Household's decision to go for a toilet is largely an economic decision of the head of the household along with the female counterparts, which is driven by the perceived benefits of time-saving, improved health, good living standards, protection from vector-borne and water-borne diseases, prevention of loss of employment, and the ability to bear the cost of building a toilet. What is important to remember is that these benefits are high under certain conditions, and fully realized under certain other conditions.

Sometimes, it is also a social decision, driven by the desire to maintain status in the society. But, this again is linked to the caste, economic progress and/or educational status of the family, and the number of women members in the household, etc. What is achieved through the provision of subsidy is a reduction in the private cost of building toilets for the adopter families, thereby increasing the extent of net economic benefits, even while other socio-economic factors remain the same. This would increase the chances of adoption of toilets to an extent. This means that the extent of subsidy for construction of toilets should be decided by the socio-economic characteristics of the families, if we want to provide equal opportunities to socio-economically backward and forward households.

Subsidy for toilet construction would be justified when the earning of the adult members of the family is not good, or the economic condition of the family does not allow investing in a toilet with own money, or the family belongs to a backward caste, but the other 'conditions' mentioned above are present. These conditions include presence of educated adults and school-going children in the family. As the analysis of adopter households clearly indicated, if the family members, especially women have good education, the extent of use of improved toilets is very high. But, it is also evident from the diagram that if these conditions are absent, greater efforts through IEC will be required for the families to recognize the value of practicing improved sanitation, apart from providing subsidies.

But, 'subsidy for toilet construction' needs to be exercised with a lot of caution, and system for regular monitoring needs to be in place to ensure that the infrastructure is properly used and the desired welfare benefits are produced. The most important aspect is that the infrastructure built is of good quality and as per standard specifications of a toilet-having sufficient pit size, made of standard materials, with adequate space and strong superstructure and good ventilation) and is easily accessible from the dwelling. Overemphasis on target achievement would only lead to misuse of funds by the intended beneficiaries, without producing the desired results.

Large number of households take the benefit of subsidy schemes to construct the toilet at a very low cost, but still do not use them for the intended purpose because of the competing priorities. As past survey in Karnataka and the present survey in Nizamabad and Krishna districts of Andhra Pradesh have shown, the economically backward families, especially those belonging to OBCs, scheduled castes and scheduled tribes, use the space created for keeping small ruminants, agricultural implements and sometimes even grain bags.

In the case of toilets for rural households, the subsidy can be released in a few installments over a period of 1-2 years, based on the report of monitoring obtained from authorized persons in the field. This would create incentive among the households, who had invested their own funds for construction, to use the system properly and would help prevent misappropriation of public funds. Over and above, installment payment of subsidy benefits would make sure that only those families which are actually concerned about improved sanitation and hygiene would be approaching the agency for availing of the scheme.

But, there are long-term strategic interventions to promote improved sanitation in rural areas. They are: enhancing the literacy levels of the rural households, particularly educating girl children; improving the livelihood opportunities for adult members of rural households. This would automatically increase the opportunity cost of defecating in the open and help family members realize the health benefits of improved sanitation. At another level, better education would make the family members more conscious about their dignity.

Providing Household Connections of Water Supply?

The motivation to use a toilet for personal hygiene and sanitation is largely behaviour-related, and therefore can change from person to person. Within the same family, the understanding of the health benefits of proper use of toilet would change. Also, the ability to use the toilet would differ across the age groups. If the water supply source is distant, then the young members of the family may not always find it convenient to use the toilet as considerable amount of water would be required for flushing. But, such constraints would be non-existent if water supply is available within the dwelling premise. Same is the case with hand washing. If water is available within the dwelling premise or if tap connection is available, then the motivation to do hand washing would be higher, irrespective of the age. Our analysis has shown that access to water supply has a significant bearing on sanitation and hygiene practices. Thus, if the rural households are to derive maximum benefit out of having improved latrines, it is important to offer piped water supply, along with providing hygiene education.

What IEC Education Can Do?

It is important to recognize the fact that one cannot motivate people through IEC campaigns to construct improved latrines. One can only create conditions under which people get motivated. IEC education cannot alter the socio-economic conditions of the households, which actually determine the opportunity cost of not having toilets. IEC can only change the way some of these costs are appreciated by the members of the households, the most important of which is the health consequences of not having proper sanitation. Some of the other costs are safety and security of women and children, school children's delay in attending classes, and reduced ability of adults in reporting for work on time. IEC can also help people to derive maximum benefits out of having an improved latrine, by providing knowledge and information about the benefits of best hygiene practices such as 'hand washing'. Therefore, it can make a difference for those HHs which have already built toilets, but do not use them and practice open defecation.

It is important that the IEC programmes lay stress on the outcomes (of adoption of improved latrines) which are easily perceived and which people can relate to. More importantly, the economic gains, which can accrue the individual households in the short run, need to be highlighted in such programmes, rather than the welfare gains, which the society at large can get benefitted in the long run. The IEC materials should be tailor-made, keeping in mind the socio-economic profile of the target communities. For instance, in congested localities, which do not have sufficient open space, the IEC campaign can highlight the benefits of privacy.

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Implications of Ending Manual Scavenging in India

Dr. Bindeshwar Pathak*

Since the Puranic period, India has had an age-old tradition and practice of defecation in the open. There were no toilets inside the houses as it was believed that it is hygienic and healthy to go outside for washing off physical impurities. Another contributory reason for this practice was the tropical climate. This approach towards sanitation and the science of personal and community health was maintained till the Puranic age and even later. It was during the Indus-Valley civilization that the concept of toilet was developed with proper sewerage and drainage system. Later, during the Vedic age the toilets were built inside the house and the human excreta was removed and cleaned manually by a particular caste of the society who were treated as untouchables. This practice continued to be followed during the Buddhist, Mughal and British periods and is being followed even now. The sewerage system was introduced by the British rulers in India in 1870 but only in the civil lines. In other areas inhabited by indigenous people there was widespread phenomenon of open defecation or existence of dry-latrines cleaned by manual scavengers.

The greatest scourge of untouchability is felt by manual scavengers whose daily living is based on cleaning faeces from public and private latrines and disposal of dead animals from the village set-up. Deemed to be a polluting and filthy occupation, this job is preformed exclusively by Dalits and that too, a sub-caste of Dalits who are considered even by other Dalit sub-castes to be wretched and 'untouchable.' Manual Scavenging is not only a violation of human rights but also a disgrace to human dignity and humanity at large. Manual scavenging has continued to exist in India, despite governmental efforts by way of enacting legislations, and social preaching by people like Mahatma Gandhi and his disciples in British India.

Manual scavengers are among the most excluded and exploited communities among the Dalits. They are considered to be the lowest in Hindu caste hierarchy and, therefore, suffer multiple forms of discrimination and social exclusion at the hand of caste Hindus and the state's functionaries. They are found in almost all cities of India—where they sweep the streets and manually engage in carrying night-soil. Women from these communities are the worst victims as they constitute more than eighty per cent of the workforce of manual scavengers. Apart from the social stigma that they suffer, their work

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is low-paid. Further, it causes various health problems, those who engage in this work being exposed to the most virulent forms of viral and bacterial infections that affect their skin, eyes, and limbs, respiratory and gastrointestinal systems. A large number of manual scavengers have died while cleaning sewage.

EARLY EFFORTS FOR ABOLITION OF SCAVENGING IN INDIA: MAHATMA'S VISION

It was Mahatma Gandhi, who first focused the attention of the government on this problem. When Mahatma Gandhi came to India from South Africa to lead the freedom movement, his attention was drawn towards the problems of defecation in the open and the prevalence of scavenging. In 1901 when Mahatma Gandhi attended the Calcutta Conference of the Congress, he himself cleaned the night-soil scattered around the conference area and urged others to do likewise. Further, Gandhi recommended two practices: firstly -after defecation, to cover the human excreta with soil, lest it becomes a source of diseases and pollutes the environment-a method which he called "Tatti Par Mitti", soil upon night soil, and secondly, to use trench latrines for defecation. He also said that the system of scavenging should be abolished and the scavengers should be treated at par with others, so as to bring them in the mainstream of the society. Unfortunately, however, neither he nor his many disciples could make much headway towards the abolition of the system during the British period and also during the early years after independence.

In the earlier Five Year Plans, the entire allocation earmarked for sanitation was spent on sewerage only, yet there are hardly 929 towns and cities out of 7933 towns (2011 census) in the country with sewer lines. None of them, however, cover the entire municipal city areas; leave alone the adjoining suburbs included in the municipal limits. It is rather strange that even after 64 years of independence only 160 towns have sewage treatment plants (STP) while the remaining 769 towns have sewage generation but there are no sewage treatment facilities with the result that the entire sewage goes underground contaminating the water and polluting the rivers thereby posing environmental health hazards to the people. In the rural and peri-urban areas, open defecation and manual scavenging has continued.

SULABH SANITATION MOVEMENT

The institutionalized arrangement to force unclean work upon a section of the population and their social degradation could not be erased from the face of India in spite of significant socio-economic development in the country after independence. I took up the challenge in early 70s with single-minded commitment and dedication. I realized that to liberate and rehabilitate the scavengers, the worst victims of institutionalized discrimination over the centuries, and to bring them back in the mainstream of the society, is a challenging task and would require multipronged strategy. My strategy for liberation of the scavengers consists of a mixed package of technology, rehabilitation and social reform. This holistic approach which I developed through years of struggle and experimentation during the 70s and 80s, is radically different from other social movements in that it combines technology with social realism. Imbued with the determination to devise and develop an appropriate alternative to replace the obsolete and obnoxious system of manual scavenging, I carried out extensive studies and research and finally got a solution to this problem.

I innovated a low-cost two-pit pour flush water-seal toilet technology which proved a viable and most effective alternative to replace the privies which required manual scavenging. This technology was given recognition by the Govt. of Bihar, Govt. of India and other state Govts. The National seminar organized by WHO, UNICEF in 1978 at Patna recommended this technology for adoption by other countries as well. This technology is affordable, appropriate and culturally acceptable and ideally suited to the conditions in the country. The construction, operation and maintenance of sewerage and septic tank is cost prohibitive and a country of India's size with constraint of resources can ill-afford to adopt them. I have been deeply inspired by the Gandhi's ideology because the Brahmin in me had already developed a sense of revulsion against the discriminatory and dehumanizing caste practices of Hindu social order. I followed Mahatma Gandhi's philosophy for the abolition of manual scavenging and eradication of untouchability and the emancipation of scavengers.

IMPACT OF SULABH SANITATION MOVEMENT: COUNTRY WIDE SCALING UP

Sulabh International Social Service Organization, which I set up in 1970 has, in collaboration with local Governments, demonstrated the success of low-cost twin-pit pour flush water seal toilet technology throughout the country and abroad. So far, more than 1.2 million individual household toilets have been constructed or substituted for existing dry latrines by Sulabh and 8000 community toilets have been installed on 'pay and use' toilets at important places all over the country, out of which 200 are linked with biogas plants. Thus, more than 10 million people use these facilities every day. The census figures of 2011 released recently show that the sanitation coverage in the country has increased to 46.9 percent, 30.7 percent in the rural areas and 61.4 percent in the urban areas. This has brought down the practice of open defecation from 73 percent in 1990 to 49.8 percent in 2011. This was the impact of Sulabh's efforts in fulfilling the dream of Mahatma Gandhi, which has resulted in scaling up sanitation program country wide.

THE SOCIAL SPIN-OFF: MAINSTREAMING THE SCAVENGERS

Manual Scavenging is primarily a socio – political issue, it denies life with dignity. This is one prime reason why every attempt to address it through livelihood aspect never succeeded in eradicating it. The occupation of manual scavenging has its roots in the caste system, which renders the community invisible and powerless. Further, condition and status of women pitches this issue into the premise of gender and women's rights. They are not only forced into the occupation, but also face multiple situations of vulnerabilities and denial of rights and justice within all spheres of life. Thus, this unfortunate dalit community faces the dual challenge of 'liberation" and "rehabilitation" - Liberation from the inhumane occupation and invisibility to lead a life with 'dignity' and rehabilitation in the comprehensive terms encompassing social, religious, economic and political aspects.

Sulabh's determined and principled intervention under my leadership has liberated and rehabilitated more than 150,000 scavengers in hundreds of towns during my three-decades old campaign. But more than the numbers, Sulabh has demonstrated to the nation, and also to the world, the road to freedom and human dignity for those suffering for centuries social discrimination and untouchability. On 21st December, 2008, the pages of history turned in India when the Sky met the Earth. At my instance, the upper caste people of those houses where the erstwhile scavengers used to manually clean the toilets for ages, joined them to visit a temple (where scavengers were not allowed to enter) prayed together and had a meal together. This event was unique in the 5000 years' history of India and could go a long way in bringing harmony in the society and removing discrimination and untouchability from it.

A key to the success of Sulabh also lies in implementing their program for the liberation and rehabilitation of scavengers from the sub-human occupation of manual scavenging. They have trained more than 8000 liberated scavengers in market-oriented trades and occupations through vocational training centres set up by them at various places. The liberated scavengers who have been rehabilitated by Sulabh have acquired confidence and have joined the mainstream of the society. In July 2008, they were invited to participate in a cultural show organized by the U.N. at New York as a part of the observance of the International Year of Sanitation 2008. The rehabilitated Dalit women were allowed to enter the Jagannath Temple in Alwar for the first time and they dined with the same upper caste people who did not even let them enter their houses earlier as they were treated as untouchables. The fact that they performed Puja with Vedic Brahmins and also dined with them, has tremendous social implication for the caste ridden Indian society. It is a significant event which has helped in mainstreaming the scavengers in the society and also resulting in attitudinal change amongst the general people. The attitudinal change is of considerable relevance as at one point of time when they were engaged in manual scavenging the people looked at them with contempt. But now they are using goods, articles, eatables prepared by them gladly and treat them on a par with others. They have been now absorbed in the mainstream of the society. This achievement is of tremendous significance for the people of the 3rd world countries in terms of restoring human rights and social dignity who were denied the same earlier.

GOVERNMENT SUPPORTS THE PROGRAM: KEY LEGAL PROVISIONS

In 1901 Congress session, Mahatma Gandhi raised the issue of the horrible working and social conditions of the untouchables. It took another 90 years for the country to enact a uniform law for abolishing manual scavenging. It must be mentioned that the legal mechanism that addresses the issues and interests of the Scavengers/Dalits is based on the various provisions of the Indian Constitution. A few special laws and rules like the protection of Civil Rights Act 1955 and the Schedule Caste & Schedule Tribe Act 1989 could be applicable to the manual scavengers; however, they do not protect their interests comprehensively.

The first exclusive laws meant for Manual Scavengers, the Employment of manual scavengers and Construction of Dry Latrines (Prohibition) 1993 Act and the National Commission for Safai Karmachari Act, were enacted by the Indian Parliament in 1993. The 1993 Act is not only a penal but also a social legislation. It intends to protect and restore the dignity of manual scavengers by prohibiting the employment of manual scavengers for constructing or cleaning of dry latrines and regulating the maintenance of water-seal latrines. Since sanitation is a state subject, the Act originally came into force in six states and all the Union Territories under clause (1) of Article 252 of the Constitution of India. As of 2007, 19 States and all UTs adopted the 1993 Act, and nine States were yet to adopt it.

Inspired by Sulabh Sanitation Movement and encouraged by my determined crusade against manual scavenging, the National Govt. tabled a new and more comprehensive act, the Prohibition of Employment as Manual Scavengers and their Rehabilitation Bill 2012, on 6th Sept. 2012. It is a more comprehensive legislation and, in spite of some limitations, it is much better equipped in comparison to previous legislations for the protection of scavengers' health and livelihood. The Act is being legislated under the Concurrent List. This may force State governments to implement it in a better manner as compared to the 1993 Act, which was enacted under the State List. Secondly, it widens the ambit of the law by encompassing the sewerage system, railway tracks, septic tanks, etc. under the definition of manual scavenging. Finally, it also addresses labour welfare and rehabilitation.

The effective implementation of the current Act by the Central, State and Local governments in the country could have far reaching implications for the manual scavengers who are still working for collection of night soil from dry latrines and also for the workers employed for cleaning of sewerage and septic tanks as well as railway tracks.

It must be mentioned here that this struggle to end manual scavenging, which started with my efforts is gathering momentum across the nation and the Govt. is playing a critical supporting role in the same. However, the enforcement of legal provisions for the various social and health issues related to manual scavenging could be effective only if the same is supported by adequate awareness generation and behavioral change in the society.

HEALTH AND ENVIRONMENTAL IMPACT

Manual scavenging and health impact issues

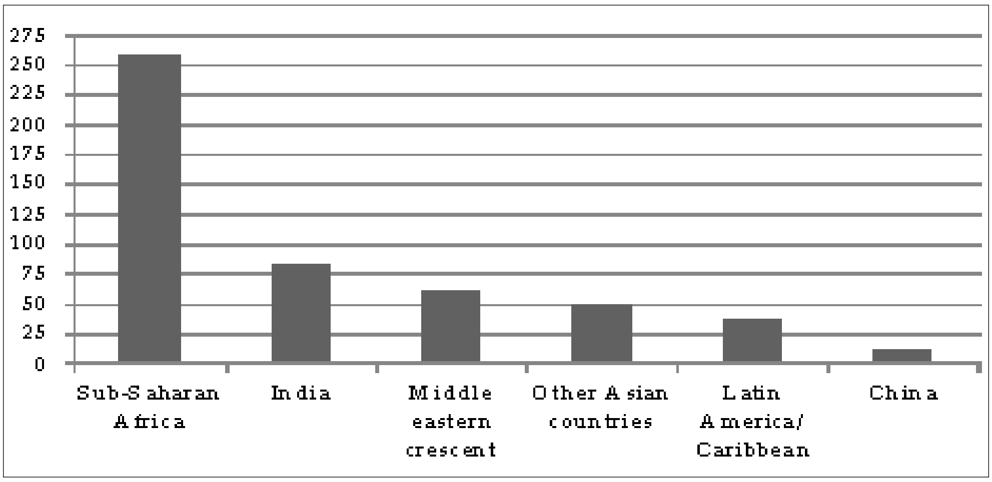
Life of a manual scavenger is at risk at every stage. Looking at health related issues will draw a clearer picture of the problem. The working conditions of these sanitary workers have remained virtually unchanged for over a century. Apart from the social atrocities that these workers face, they are exposed to certain health problems by virtue of their occupation. These health hazards include exposure to harmful gases such as methane and hydrogen sulfide, cardiovascular degeneration, musculoskeletal disorders like osteoarthritic changes and intervertebral disc herniation, infections like hepatitis, leptospirosis and helicobacter, skin problems, respiratory system problems and altered pulmonary function parameters. This is in addition to the infectious diseases which are caused from faecal contamination.

The long term health epidemiological and ecological impact of abolition of scavenging should not be judged only from the point of view of protection of health of the manual scavengers. Though it must be conceded as mentioned above, that the manual scavengers were exposed to extreme health hazards and vulnerable to various infections of dreaded infectious diseases like cholera, diarrhoea, typhoid, helminthic infections, etc. and cessation of the practice with the effective implementation of the 2012 Act would go a long way in protecting their health. However, a broader and more holistic impact of the abolition of manual scavenging should be considered from the point of view of eradication of insanitary and unhygienic system of sanitation from the community. At this juncture, let us discuss briefly the adverse impact of lack of sanitation globally particularly in the developing countries including India.

Health impact of poor sanitation

The huge burden of infectious diseases in the developing world which are primarily related to lack of sanitation, hygiene and safe water is depicted in tables and figures below. These factors are also primarily responsible for the abnormally high child mortality in countries of Sub-Saharan Africa and India. WHO data on the burden of disease suggests that approximately 1.8 million deaths and 61.9 million disability-adjusted-life years (DALYs) are attributable to unsafe water, sanitation and hygiene worldwide (WHO 2004 World Health Report). This figure corresponds to 88% of diarroheal diseases world-wide which is considered to be the attributable fraction of diarrhea due to unsafe water supply and sanitation plus the disease burden from trachoma, schistosomiasis, ascariasis, trichuriasis and hookworm disease. In India, diarrhoeal diseases alone cause more than 0.6 million deaths annually.

Figure 1: Infectious Diseases in the Year 2000-DALY per 1000 Persons



Source: Calculated based on Global Burden of Diseases data published by the World Bank

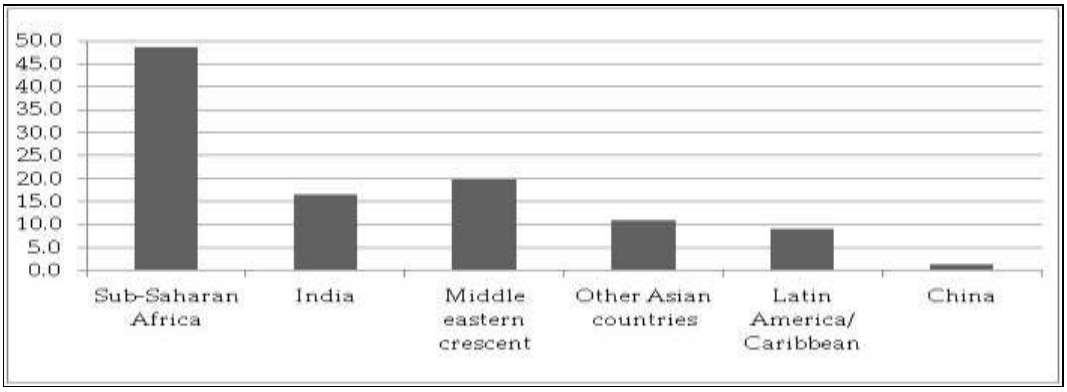
Study has shown that in slum areas of major cities diarrhoeal incidence as high as 10.5 episodes per child per year occurs on regular basis. Diseases caused by faeco-orally transmitted enteric pathogens account for 10% of total burden of disease in India. Statistics indicate that intestinal group of diseases claim about 5 million lives and about 50 million people suffer from these diseases every year.

Table 1: Select Infectious Diseases in Developing Countries

Diarrhoea	4 billion cases per year. 2.2 million deaths
Intestinal nematode infections	Infect about about 500 million people.
Schistosomiasis	About 200 million are infected. 20 million suffer severe consequences.
Trachoma	About 6 million are blind from trachoma

Source: Global Water Supply and Sanitation Assessment 2000 Report, UNICEF/WHO

Figure 2: Diarrhoeal Diseases in Year 2000 - DALYs per 1000 persons



Source: Calculated based on Global Burden of Diseases data published by the World Bank

Table 2: Regional Child Mortality & Select Determinants

	India	China	Other Asian countries	Latin America/ Caribbean	Middle Eastern Crescent	Sub-Saharan Africa
Child mortality – under 5 (per 1000 live births) in 1999	90	37	65	38	92	166
Access to improved water source in 2002 (% of total population)	88%	75%	78%	85%	83%	54%
Access to sanitation in 2000 (% of total population)	31%	38%	66%	78%	76%	54%
Female illiteracy in 2000 (% of 15-24 year olds)	35%	4%	20%	6%	31%	27%

Source: Calculated based on data from World Development Indicators (World Bank) and Global Water Supply and Sanitation Assessment 2000 Report (WHO/UNICEF)

Above table depicts regional child mortality and selects determinants. It comes out very clearly that lack of access to sanitation and female literacy are the two most critical factors behind the high infant mortality in India & Sub-Saharan Africa.

It is our collective failure during the last three decades that today 2.6 billion people lack access to improved sanitation which represented 42% of the world's population and over half of those without access to sanitation – nearly 1.5 billion people live in Asia and Africa. Unless we do something radically different from what has been attempted so far, this huge burden of diseases would continue to jeopardize the productivity and well-being of the people in these countries. Lack of sanitation is the most critical factor behind the huge burden of faecally transmitted infectious diseases in the developing countries. And it is only logical that abolition of manual scavenging and the insanitary and unhygienic dry latrines and replacement of the same with the two-pit pour flush toilets innovated by me would have significant positive health impact.

POSITIVE HEALTH IMPACT OF IMPROVED SANITATION AND ABOLITION OF SCAVENGING

During the six decades since Indian independence, significant progress has been made in health sector-the death rate per 1000 of the population has been brought down from 27.4 in 1947 to less than 10 by the end of the century. Life expectancy has increased from 32.7 to 63 years during the same period, while the rate of infant mortality has been reduced from 160 to 58, as depicted in the figures given below.

Figure 3: Birth and Death Rate in India, 1901-2001

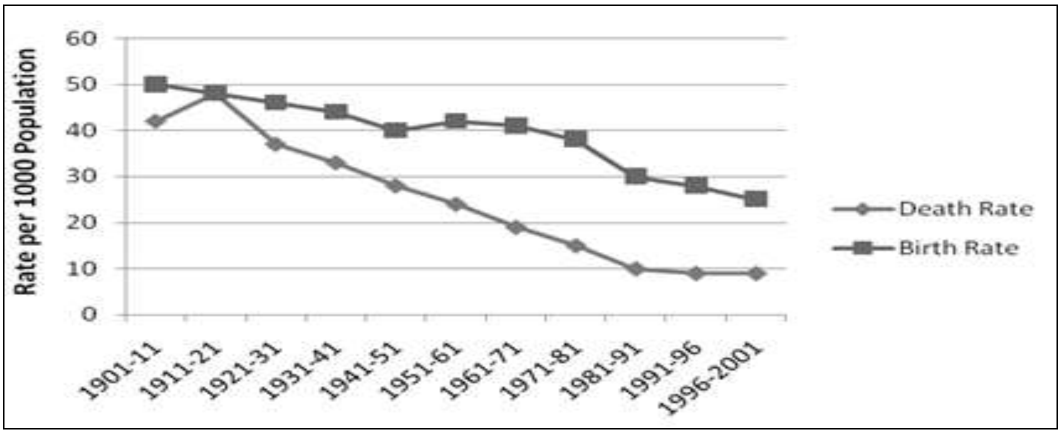
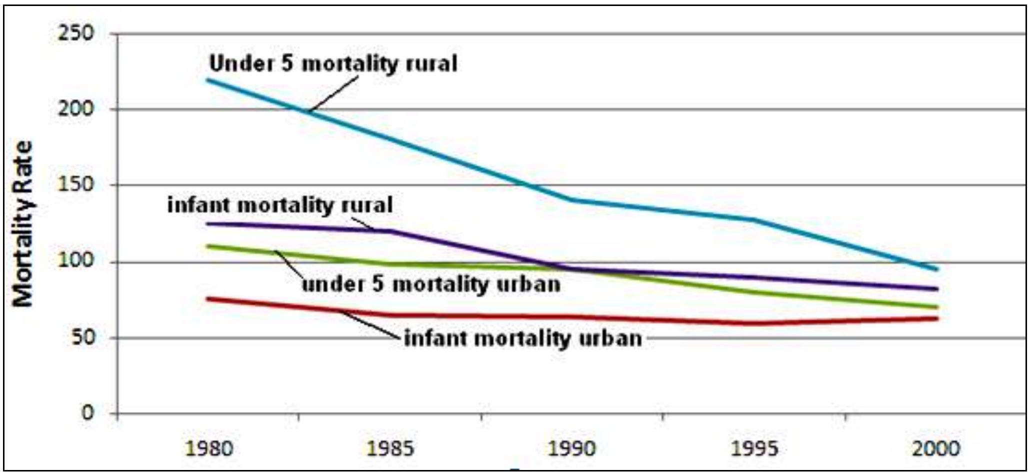
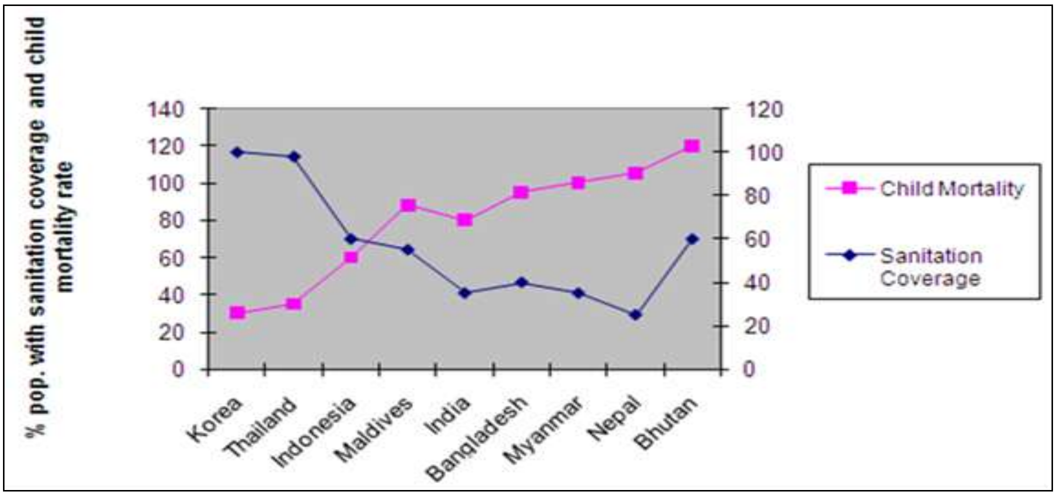


Figure 4: Trends in infant and under-5 mortality rates by residence, India, 1977-2002



It would be difficult to pin-point, precisely, the share of improved sanitation in reducing infectious disease burden in the country and increasing life expectancy. However, from the evidences provide by various epidemiological studies, it could be stated that improvement in sanitation plays the most critical role in improving health in the community.

Figure 5: Deaths due to infectious diseases worldwide vis-à-vis sanitation coverage by the WHO (1990)



Source: UNICEF End Decade Databases and Global Water Supply and Sanitation Assessment

Both manual scavenging and open defecation were responsible for high infant mortality and huge burden of infectious diseases particularly diarrhoeal diseases in the society. In almost all small and medium towns where dry latrines with manual scavenging existed, faecal pollution of the environment was of a very high degree. The night soil collected by the scavengers from the dry latrines used to be disposed off in the trenching grounds which were extremely insanitary and a potential health hazard both to the scavengers as well as to the general public. The working conditions of the manual scavengers posed a serious risk for their health. On the whole, the abolition of manual scavenging, an introduction of safe sanitation (Two pit pour flush toilets) resulted in significant and long term improvement in the urban and rural environment as well as health of the community.

SUMMARY AND CONCLUSION

Manual scavenging is a shame to the modern civilization in the 21st century. For centuries, the scavengers have been subjected to social exclusion and discrimination based on untouchability. Abolition of manual scavenging in particular and untouchability in general is a constitutional mandate in independent India. It is also a social, moral and ecological agenda for the nation. In spite of the efforts of great national leaders like Mahatma Gandhi during the British period and his followers after independence, the system continued unabated, till the 70's. The invention and innovation of two-pit pour flush toilets and the concept of pay and use public toilets made it possible to replace the dry latrines and do away with the dehumanizing system of manual scavenging. The struggle spanning four decades resulted in nationwide scaling up of the sanitation program and abolition of manual scavenging from most of the cities, and peri-urban areas of the country.

Though the onus of eradicating manual scavenging rest on the state, the efforts by the National Govt. during the early years after independence could not make much headway. The movement has gathered momentum and the Government has enacted special legislation and instructional mechanisms for prohibiting the system of manual scavenging (Acts of 1993 and 2012) and protecting their health and occupation. Dry latrine and manual scavengers still exist in public establishments like the railways, municipal corporations, etc. and private houses in many parts of India, defying the mandatory provisos of law and morality. It would require a joint effort by the government and NGOs like Sulabh International to fulfill our constitutional and democratic commitment for the total abolition of manual scavenging. This could be the best way that the nation would pay its homage to Mahatma Gandhi and fulfill his dream of a clean, sanitary and inclusive India.

Creating an Economic Value for Wastewater through Industrial and Agricultural Reuse

Joseph Ravikumar, Rajiv Raman and Shubhra Jain*

India has witnessed changing trajectories of urban growth in the past and is now poised to have more than double of its present urban population during the next 20 years. As a result of the unprecedented growth, it is estimated that around 50 per cent of the total urban water demand will be unmet by 2030. Additionally, the country's water resources, including rivers, lakes and groundwater are grossly polluted and contamination is increasing at an alarming rate. While India's water resources are impacted by point source and non-point source pollution, the treatment and reuse of wastewater thereof, provides an opportunity for environmental clean-up and meeting the growing water demand, not just for the urban sector but also potentially to satisfy industrial and agricultural water requirements. A financial cost-benefit model was developed to quantify the overall monetary benefits of wastewater recycle and reuse for industrial, domestic and agricultural applications. This paper examines the strategy for wastewater recycle and reuse in some select cities of India where such options have been exercised and demonstrates the economic benefits of wastewater recycle and reuse. The paper also examines the potential for reuse of treated municipal wastewater in agriculture and the economic benefits thereof, including secure source of irrigation supply, nutrient content in the wastewater and an alternate source for the state to meet agricultural demand.

INTRODUCTION

Urban India is growing rapidly and poses significant challenges for the provision of urban infrastructure and services like water, sanitation, solid waste management, and drainage. While 87% of the country's urban population have access to household or community sanitation, the collection, treatment and disposal of wastewater is a cause for concern. With just a third of the households covered by sewer networks, 47% of households relying on on-site sanitation systems, and the grossly insufficient treatment capacities in urban centres, the ensuing discharge of untreated or partially treated wastewater is the reason for the contamination of 80% of the country's surface water (CPCB, 2007).

Treatment and reuse of the wastewater provides an opportunity for not only environmental clean-up, but, also to meet the increasing water needs. In addition to the

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recycled water becoming an additional and valuable water source, there are opportunities to recover nutrients and utilize energy from urban wastewater. The recovery of phosphorus and potassium is particularly attractive given the fact that India imports most of the phosphorus and all of the potassium to meet existing demand.

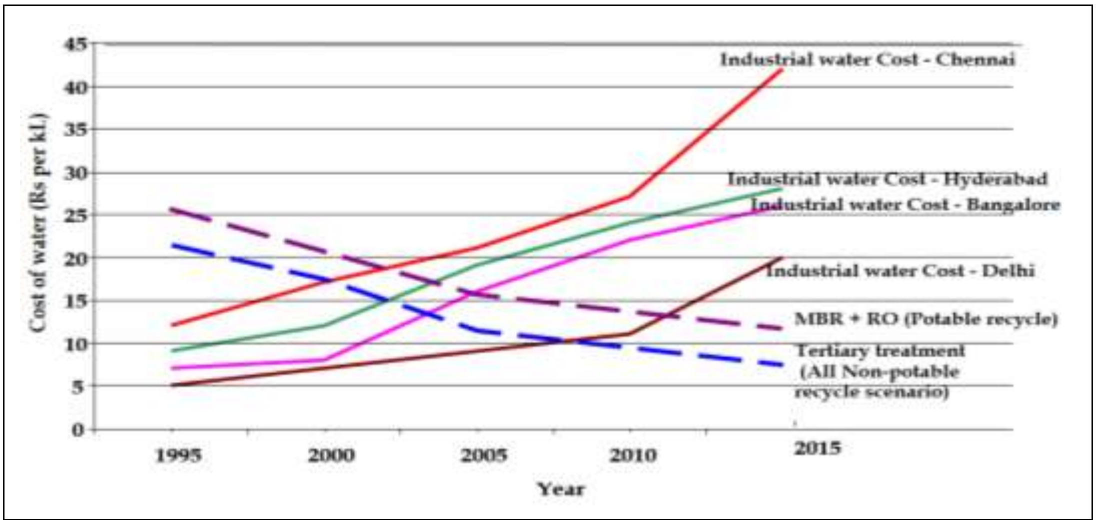
Below is given an indication of the scale of both the challenge and the opportunity in urban water recycling in India:

- 723 of India's cities and towns, with population of 50,000 and above, generate about 38,000 million litres per day (MLD) of the total wastewater (CPCB, 2009).
- In these towns, the wastewater treatment capacities total up to only 31% of the wastewater generated. At least 67% of the wastewater generated from Class I cities and more than 90% wastewater generated from Class II cities in India is not treated and is therefore unavailable for beneficial reuse of wastewater. With current population growth (1.7% per annum) and current rate of urbanization (3% per decade), the urban population is expected to increase by more than 50% from 377 million in 2011 to 590 million by 2030 (MGI, 2010), with a proportionate increase in the volume of urban wastewater, to nearly 60,000 MLD.
- If 80% of urban wastewater could be treated by 2030, there would be a total volume of around 17 billion m3 (BCM) per year; an increase of around 400% in the volume of available treated wastewater!
- This additional 17 BCM treated wastewater resource is equivalent to almost 75% of the projected industrial demand in 2025 (MoWR, 2006) and almost a quarter of the total projected drinking water requirement.

In addition, while the cost of supplying water to industries (see Figure 1) has increased over time, technological advances have made the recycle and reuse of wastewater an attractive option for meeting their growing water needs for non-potable applications (Kelkar, 2012).

This paper discusses the opportunities for recycling treated wastewater for industrial and agricultural uses. The paper also presents a discussion on the financial feasibility of implementing industrial reuse based on financial cost-benefit model developed to estimate the monetary benefits of wastewater recycle and reuse and presents the results from two southern cities where options have been exercised and clearly demonstrates the benefits of wastewater recycle and reuse. The paper then presents a preliminary analysis of the environmental and economic benefits of using treated wastewater for irrigation in agriculture, an adaptation of what is already happening in peri-urban India and examines the areas for more focused research.

Figure 1: Trends in cost of water and treated wastewater



Source: Adapted from Kelkar, 2012

MATERIALS AND METHODS

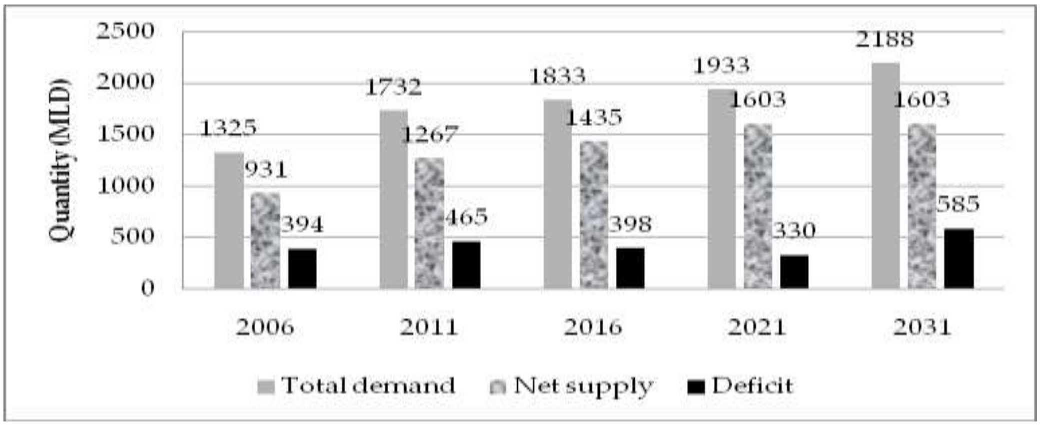
Industrial Reuse:

A mathematical model was developed to evaluate the monetary benefits of wastewater recycle and reuse. The model examines the ability to meet the wastewater need and also highlights its economic benefits to the water utility at the utility and plant level. The model considers the options of fetching water from a distance of 135 kms (involving multistage pumping) as against wastewater recycle and reuse and the benefits to the utility in meeting their operation and maintenace needs. Further, we also examined the benefits of wastewater recycle to industries in the context of water availability and environmental sustainability.

Agricultural Reuse:

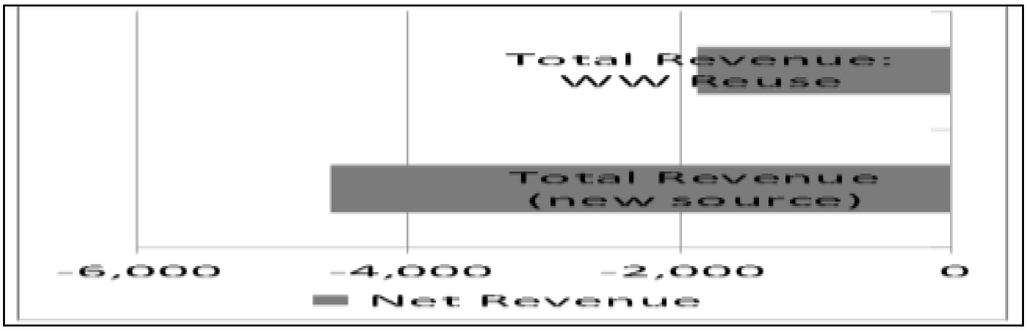
The analysis of the benefits from reuse of treated wastewater for agricultural reuse is based on information acquired through discussions with reputed national and international research agencies on the use of wastewater for irrigation, and review of published and ongoing studies on the impacts of treated wastewater use on agricultural yield, nutrient requirements and irrigation water costs.

Figure 2: Water Supply Projections



Source: Camp, Dresser & McKee – International (CDM), 2005

Figure 3: Revenue comparison for wastewater recycle and distant surface water option



Source: Raman, 2009, Economic valuation of wastewater – An urban perspective

RESULTS AND CONCLUSIONS

The results of our analysis highlight the following:

1. Reuse of treated wastewater by industries for non-potable applications frees up fresh water which could be used by cities / utilities to augment or meet the growing water demand as can be seen in Figure 2.

2. In order to examine the benefits of wastewater recycle and reuse to water utilities, we compared the impact on the operating revenues of the water utility as a result of augmenting water supply. The two options compared were (a) getting water from a surface water source at a distance of 135 kms with multi-stage pumping, and (b) wastewater recycle and reuse. Supply of treated wastewater for non-potable application to industries, frees up the

stock of water with the utility enabling augmentation of water supply to the city. All other things remaining the same (tariff, distribution and revenue collection efficiencies), the utility which was already loss-making continues to be so with increased coverage of consumers and enhanced supplies. However, the projected losses are brought down significantly if the wastewater reuse option is exercised, by a factor of 2.5 (see Figure 3), compared to the distant water source and pumping to the city option.

3. In order to examine the benefits of wastewater recycle and reuse on sewage treatment plant operations, we looked at the revenue from the sale of treated wastewater and the operation and maintenance cost of the sewage treatment plants. The analysis of operations data from four sewage treatment plants in a city and the revenue data of the utility shows that the revenue from the sale of treated wastewater exceeds the operation and maintenance cost of the treatment plants by about 20%.

Table 1: Summary of Wastewater Recycle and Reuse at Plant Level

S. No.	Parameter	Value
1.	Quantity of treated wastewater sold* (MLD[1])	36
2.	Price of treated wastewater (Rs./KL[2])	8 -10
3.	Annual revenue from sale of wastewater (Rs. Million)	100
4.	Annual operation and maintenance cost (Rs. Million)	84
5	Plant operation maintenance cost met from sale of treated wastewater (%)	120

Source: Water Sanitation Programme, World Bank, 2013. Note: * - at four plants

4. Recycle and reuse of wastewater also benefited a petro-chemical industry which in the past depended on water supply through tankers and even had to be shut down for want of water on a few occasions. During a 20 year period, the cost of water also increased seven fold, as the demand increased. Recognizing that the water supply from the water utility was not only unreliable but also uneconomical, the industry set up a wastewater recycle plant to treat the partially treated wastewater from the water utility. The cost of recycled wastewater to the industry worked out to Rs. 45/KL as compared to Rs. 60/KL for the water purchased from the water utility. Besides being economically attractive, this quantum (of partially treated wastewater supplied) was also able to meet the current and future water needs of the industry.

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1. MLD – Million Liters Daily
2. KL – Kilo Liter

Recycle and Reuse of Treated Wastewater for Agriculture

5. Several countries have adopted the recycle and reuse of wastewater to varying degrees and for a range of activities, including for agricultural water demand. Arid parts of the USA, Israel, Mexico, China, Spain, Namibia, and several Middle Eastern countries recycle their wastewater as irrigation water. China, India, Mexico and Chile each has a cultivated area of more than 40,000 ha that is irrigated with untreated wastewater (The World Bank, 2010). The most significant benefit realized in these countries is the creation of an alternate, reliable source of supply for meeting appropriate uses, at a lesser cost than potable water. Countries using treated water for agriculture also value the environmental benefit created by avoiding the inflow of excess nutrients in surface water bodies resulting in environmental pollution and eutrophication. Still others, such as the City of Windhoek, Namibia, have realized economic benefits from the project to recycle wastewater related to increased land value from 2,500 to 20,000 EUR per ha due to water availability and creation of jobs and higher incomes (UN Water, 2011).

6. In India, the urban wastewater generated (estimated currently at about 38,000 MLD), if treated and channeled to meet agricultural irrigation requirements would provide 14 BCM of irrigation water, which could potentially irrigate an area ranging between 1-3 million hectares. This potential would depend on the type of crop cultivated and its irrigation practice. While this quantum might not seem significant compared to the total irrigation water demand in 2025 (910 BCM as per MoWR estimates), its significance should be viewed in relation to the national irrigation effort during the plan periods. During the 10th Plan period, the major and medium irrigation potential created was 4.59 million hectares, while the surface water fed minor irrigation potential developed was 0.71 million hectares (MoWR, 2011). The wastewater irrigation potential (taken at 2 million hectares) is 44% of the major and medium potential created and nearly three times the surface water based minor irrigation potential created in the 10th plan.

7. In addition to providing a reliable source of irrigation, wastewater also contains valuable nutrients (nitrogen, phosphorus and potassium) which could reduce the need for synthetic fertilizers by 40% (Minhas, 2002; Silva and Scot, 2002). In their review of wastewater generated in the coastal cities, Central Pollution Control Board (CPCB) estimated a nutrient load of 347.56 tonnes per day in about 5,500 MLD of wastewater generated from these cities daily (wherein about 10% wastewater received some form of treatment). Several other studies have also estimated the nutrient potential in

wastewater which ranges from 0.63 – 0.73 tonnes/MLD (adapted from Minhas, 2002; Silva and Scot, 2002; CPCB, 2002; WII, 2006). Thus, the total wastewater generated from Class I and II cities in India has an estimated nutrient load of about 2,595 tonnes. At an estimated nutrient value of Rs. 4,220/tonne (CPCB 1996 estimate), this translates into a monetary value of about Rs. 288/MLD of wastewater or about Rs. 1 crore daily for the total quantum of wastewater being generated by Class I and II cities in the country at present.

8. Various studies (WII, 2006; Londhe et al, 2004; Amerasinghe et al, 2013) also suggest increased economic benefits for the farmers engaged in cultivation from use of treated and untreated wastewater as compared to freshwater, due to an increase in yield, lower fertilizer requirement, and improved quality of yield resulting in higher prices for the produce. The following table summarizes the incremental benefit reported as accruing to farmers engaged in cultivation using wastewater as compared to freshwater.

Table 2: Incremental benefits delivered due to wastewater irrigation in select cities

City	Crop cultivated	Increase in yield (%)	Decrease in fertilizer consum-ption (%)	Increase in pesticide consumption (%)	Average Annual Incremental benefit** (Rs./hectare)
Indore	Wheat (Rabi) / Vegetables (Summer)	30-40%	50%	Almost double	36,752
Nagpur	Wheat (Rabi) / Vegetables (Summer)	30-40%	33%	Almost double	26,951
Jaipur	Wheat (Rabi) / Vegetables (Summer)	30-40%	50%	Almost double	37,790
Bangalore	Rice (Rabi), Sapota and Flowers (Summer)	30-40%	100%	Almost double	33,849
Ahmedabad*	Rice and wheat (Rabi)	-	-	-	-14,640
Delhi	Okra	67%	60%	Increased by 50%	8,500
Kanpur	Paddy and wheat	Reported a decrease in yield	-	-	6,166 (paddy) 954 (wheat)

Source: Adapted from Amerasinghe et al, 2013; WII, 2006; Londhe et al, 2004

Notes: * This decrease in net benefit in Ahmedabad is believed to be due to higher levels of pollution in Ahmedabad as compared to other cities. The study also reported that continued application of partial / untreated wastewater affects soil fertility increasing fertilizer and pesticides consumption. Thus farmers engaged in wastewater irrigation were spending more on fertilizers and pesticides, as compared to farmers practicing freshwater irrigation.

** This incorporates the impact of increased yield, change in fertilizer and pesticide use, wherever reported.

9. More than 60% of the country's irrigation requirements are met by groundwater (IDFC, 2011), which relies on energy use. Considering the potential utilization of treated wastewater in agriculture, an illustrative scenario is compared with the national estimates of area (in hectares) irrigated by groundwater in the following Table (3).

Table 3: Comparison of Groundwater Irrigation and WWI Potential for Different Crop Season

Irrigation type	Irrigated area / Potential for irrigation
Net Irrigated area by Groundwater	39 MHa
Potential through WWI*	2 MHa
Potential that can be met through WWI (%)	~5%

Source: DAC, 2013

Note: *Calculated based on average annual irrigation requirements of 700 mm.

The energy required for groundwater irrigation is usually sourced through grid electricity (subsidized significantly by the State Governments) or by using diesel pump sets, and either of these mean a significant financial expenditure for the individual farmer or for the state. Also, the increasing use of groundwater has led to the depletion of groundwater tables and allied problems in many parts of the country.

As is evident from the table above, the use of treated wastewater for irrigation has the potential to reduce groundwater requirement in these areas and hence reduction in the associated energy use. With the availability of a continuous supply of wastewater, the reliance on groundwater extraction could be optimistically expected to reduce significantly. There are currently about 18 million electricity-powered pump sets reported in use (BEE, 2011). Considering the substitution potential of wastewater irrigation and assuming a reduction of pumping use by at least a third of the current use in these wastewater irrigated areas, the savings in grid electricity supply requirements would be significant and are estimated to save (the state government and the electricity utility) about Rs. 600 crore annually .

10. The 13th Finance Commission recommended charging Rs. 1,175 in major irrigation command areas and Rs. 588 in minor irrigation command areas for one hectare of irrigated land, to cover operation and maintenance expenditure of irrigation projects. This is a significant increase from the current irrigation fees charged. However, simple calculations indicate that

this works out to only 10-25 paise per kilo litre, depending on assumptions of crop and water use. The cost of treating wastewater is significantly high compared to this. While treated wastewater presents potential economic and environmental benefits to consumers, city governments and states - an assured and reliable water supply, the nutrients present in the wastewater, and avoided costs of groundwater pumping – utilities and city governments will need to explore sustainable business models aimed at different user categories – industry, agriculture, institutions - which in collaboration with partner agencies ensure financial viability, follow water allocation rules and support peri-urban agriculture.

11. Wastewater use in agriculture is inherent with risks to human, plant, soil and water health if not treated to appropriate levels. Microbial risks to public health arise from microbial pathogens (disease-causing organisms) contained in domestic wastewater; chemical risks to health need to be considered when untreated industrial wastewaters are discharged to public sewers and contaminate municipal wastewaters. There may also be risks to plant health and consumer health (due to high salinity or elevated levels of heavy metals) and environmental risks (soil and groundwater pollution) when effective treatment programs are not instituted or enforced (WB, 2010).

In India, the installed sewage treatment capacity in Class I and Class II is 11,788 MLD (CPCB, 2009), adequate to treat only 31% of the wastewater generated in these cities. Therefore, an important consideration when using wastewater for irrigation is the extent of treatment provided and the contamination with industrial and other non-domestic wastewater such as hospital waste, etc. Several studies have undertaken assessment of wastewater, soil and crop quality across various microbiological and bio-chemical parameters and most studies report elevated levels for these quality parameters in the wastewater as well as in the soil and cultivated produce (Amerasinghe, et al, 2013; PSCST, 2007; WII, 2006). Most studies also report rampant mixing of treated wastewater with untreated sewage, as well as contamination with industrial effluent at selected study sites. The quality of the wastewater and the treatment provided are important considerations when using this valuable resource for irrigation.

CONCLUSION

The review has shown that the benefits of wastewater recycle and reuse are:

- Availability of a continuous and reliable source of water;
- An economical option to meet a city’s water demand;
- Improves viability of STPs when used to meet industrial water requirements;

- Sustainable option for industries;
- As a potential nutrient source for agriculture, with potential to reduce fertilizer requirements (up to 50-100% reduction as compared to freshwater) and an associated beneficial impact on crop yields (upto 30-60% increase reported by various researchers);
- Results in overall economic benefits for the farmer due to higher yields and lower costs (on average, an incremental benefit of about Rs. 17,000/hectare/year has been reported across the studies included in this review).

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Experience of Wastewater Treatment Technologies: A Case Study of Vapi Waste and Effluent Management Co. Ltd.

Rajesh Doshi*

As everyone knows the industrial effluent or wastewater characteristic changes depending on the type of industrial activity. Recently, in India, we have clusters or industrial parts wherein it is dominated by one type of industrial section only, whereas in the earlier days there were only industrial estates and all types of industrial activities were permitted within the same estate.

Vapi is one such industry which was established way back in 1967 and in those days the treating of effluent was not a focused area. Accordingly, Vapi is a mixed cluster of industries related to pesticides, pharmaceuticals, bulk drugs, re-cycling paper mills, dyes, pigments, textiles, etc. which are spread physically at random in the estate and are of different sizes.

As this estate was established many years ago, people had not made provisions for waste treatment i.e. primary, secondary, tertiary treatments. As a general awareness for protecting environment and treating the effluent is increasing and becoming mandatory, drainage systems were established in Vapi . The industries were asked to carry out at least primary treatment for small-scale industries and secondary and tertiary treatment for large and medium-scale industries, as the case may be. Their effluent is discharged through the common underground networking of drainage system in the estate leading to the end of pipe treatment before releasing after treatment in the high tidal zone in the Arabian Sea. With this background it will be easy to understand the choices available for treatment done for the Vapi area through Common Effluent Treatment Plant (CETP). The characteristics that need treatment include:

(1) Neutralization of effluent; (2) Removal of silt, grit, suspension particles; (3) Removal COD and BOD contributed by organic compounds; (4) Oil and grease, heavy metals, ammonical nitrogen, phosphate, phenols need a treatment and the various unit operations available are flash mixture, chemical dosing, clarifier, floculator, equalization tanks, etc.

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In a mixed chemical cluster like Vapi with the cocktail effluent received at the end of the pipe, all these ingredients have to be taken into consideration for designing the system and thorough strategy has to be adopted for treating such an effluent.

Treatment available is broadly classified as physical, chemical and biological treatment. The various conventional treatment unit operations include grit removal or split chambers, oil and grease skimmer, dissolved air floatation, mixers or diffused aeration, aeration channels, sand filters, and activated carbon filters. Nowadays, advanced technologies are developed which include oxidated and mechanical separations, various types of filter media and reverse osmosis. The membrane filters or mechanical filters are also available, whereas for an oxidative or chemical reaction, the other unit operations such as electro oxidation or electro chemical co-ordination are also important techniques developed for treating wastewater. Similarly, the ozonation and some of the process intensification units such as hydro-cavitation, ultrasonication are employed. Besides, another process some of the treatment include the combination of above unit operations can be collectively classified into anaerobic digestion, aerobic digestion or activated sludge passes, Moving Bed Bio Reactor (MBBR), Membrane Bio Reactor (MBR), and Sequential Batch Reactors (SBR) with the various physical treatment unit operations.

Considering the complexity of the inlet quality at Vapi CETP we have moved from conventional treatment scheme over a period of time and have tried out various latest technologies to improve the performance of the treated effluent. Our experience in the actual operating plants and their cost effectiveness at Vapi CETP are discussed in the following para.

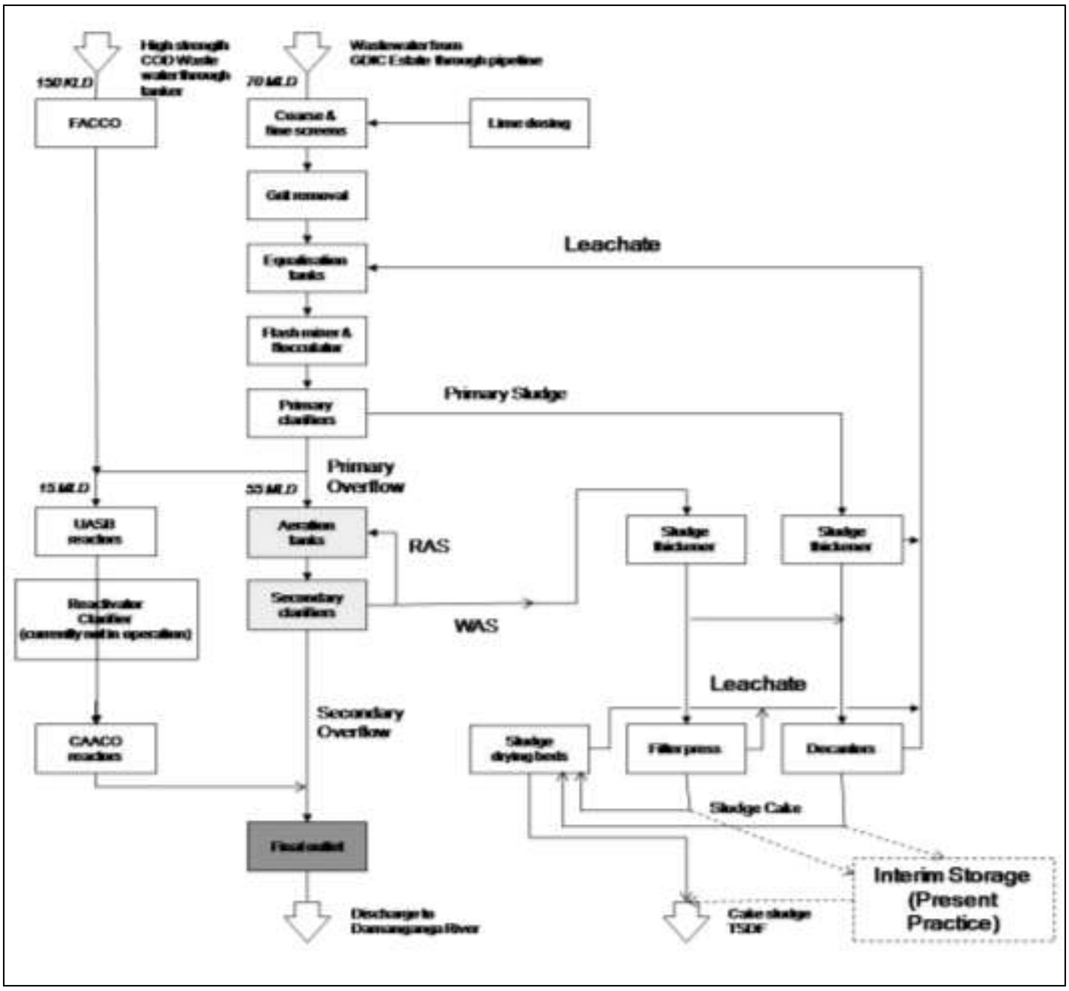
TREATMENT TECHNOLOGY ADOPTED AT EXISTING PLANT:

CETP is designed for the following wastewater characteristics: pH 5.5-8.5, suspended solids - 300 mg/l, BOD - 400 mg/l and COD - 1000 mg/l. As per the norms set by GIDC (Gujarat Industrial Development Corporation) earlier and later maintained by Vapi Waste and Effluent & Management Company Ltd (VWEMCL), all the industries discharging their effluent into the CETP for ultimate treatment shall conform to the stipulated standards of effluent quality prescribed by the Gujarat Pollution Control Board (GPCB) for all the parameters except suspended solids, BOD and COD, which should be in conformity with CETP inlet standards.

The various unit operations and processes of CETP as per the original design and subsequent modifications are detailed hereunder:

(i) Screen Chamber
(ii) Grit Chamber (2 nos.)
(iii) Equalization Basin (3 nos.)

(iv) Flash Mixers (2 nos.) and Flocculator (4 nos.)
(v) Primary Clarifiers (2 nos.)
(vi) Aeration Fanks (12 nos. in two batteries of 6 each)
(vii) Secondary Clarifier (2 nos.)
(viii) Sludge Thickener (2 nos.)
(ix) Sludge Drying Beds (10 nos.)
(x) Upflow Anaerobic Sludge Blanket (UASB) Reactor (2 Nos.)
(xi) Reactivated clarifier (1 No.)
(xii) Fenton Activated Carbon Catalytic Oxidation (FACCO)
(xiii) Chemoautotrophic Activated Carbon Oxidation (CAACO)



The partially treated effluent from various industries together with domestic sewage from Vapi town reaches CETP through a common closed conduit. At the inlet chamber, provision has been made to monitor the effluent quality. The effluent is first routed through screen chamber to remove the screenings. Earlier, the screenings were removed manually, however, presently mechanized screening facility has been provided. The screenings are collected and disposed in the secured landfill. The grit chamber installed with a mechanical grit removal facility is in place.

The effluent after grit removal is taken to equalization basin. Originally, fixed mixers were provided in the equalization basin for mixing and oxygenation. Due to formation of scum on the surface, the mixers were replaced by diffused aeration system. The equalized effluent is subjected to physico-chemical treatment and routed through flash mixers and flocculators followed by clarification in primary clarifiers. Spent liquid aluminium chloride (obtained from industries within the Vapi Industrial Estate) is used as coagulant and polyelectrolyte as coagulant aid in the flash mixer.

The clarified effluent is discharged into two batteries of aeration tanks operated in parallel with six units in each battery. A detention period of 21 h is provided in the aeration tank. In all 60 aerators of total 1650 HP capacity (50 nos. of 25 HP + 5 nos. of 40 HP + 5 nos. of 40 HP) are provided in the aeration tanks. The mixed liquor from aeration tanks flows to two secondary clarifiers wherein a detention period of 3.5 h is provided. Aluminium chloride solution is added at the outlet of aeration tanks to arrest the fine colloidal particle being carried over in the secondary clarifier. A sludge collection sump is provided to collect the biological sludge from where a portion of it is pumped back as return sludge to aeration tanks to maintain the desired MLSS concentration in the system.

The part of the primary clarified effluent mixed with FACCO treated effluent is sent to the Up flow Anaerobic Sludge Blanket (UASB) Reactor, where the wastewater is treated by the anaerobic treatment. The outlet of the UASB is sent to the Reactivated Clarifier (RAC). RAC is the combination of flash mixer, flocculator & clarifier. The overflow from RAC is passed through the CAACO system. The final effluent from the secondary clarifiers & CAACO system is discharged finally through a closed conduit of about 300 m length into the river Daman Ganga which ultimately joins the Arabian Sea.

MAJOR CHALLENGES FACED

Vapi Industrial estate, being mixed cluster, there are vast variations in the quality and quantity of effluent. Also, refractory organic removal is a major challenge faced in CETP operation to achieve the prescribed norms by the regulatory authority. Also, sludge handling is the major issue for the CETP operation. Moisture content is a critical parameter for sludge handling and disposal as well as suspended solid removal from the final outlet.

RESEARCH AND DEVELOPMENT ACTIVITIES

CETP is experimenting with different technologies to improve the quality of discharge as it is having concern about the aquatic life and to meet the discharge standards of GPCB. A pilot plant was constructed for carrying out trials in 2010 having the facility of primary treatment (lamella settler), secondary treatment (2 aeration tanks and settler) and tertiary treatment (sand filter, dosing tank and settler). Microbiological lab has also been established to cultivate bacteria and study their performance in removing refractive COD from secondary treated effluent by application of Bio-augmentation strategy. The trials carried out at the pilot plant are as follows:

(i) NEERI's two stage trial
(ii) ARC trial for NH3-N reduction and tertiary treatment
(iii) IWAzyme trial for COD reduction
(iv) Single and Two-stage aeration using cultures available in lab
(v) Moving Bed Bioreactor
(vi) Digester

1. NEERI's two-stage trial

NEERI initiated trial at pilot plant for reducing COD and ammonical nitrogen of secondary effluent after series of lab trials. They aimed to evaluate the treatment potential of bacteria in activated sludge and further target the improvement in removal of free ammonia and refractive COD from secondary treated effluent by application of Bioaugmentation strategy and molecular tools. Exhaustive experiments were carried out at NEERI for around six months for selecting suitable Consortia for treating the refractive COD & Ammonical Nitrogen. Finally, a consortium for treating the refractive COD & Ammonical Nitrogen was selected. Their experiments proved the importance of phosphate in enhancing the bacterial growth which acts as energy source and promotes the treatment efficiency. The trial was conducted in single-stage and two-stage aeration, the first stage having the CETP RAS culture and second stage having NEERI consortia for treating the refractory (carried over) COD. The COD removal efficiency in the first stage was 50-60% with further COD removal of 25% in the second stage which was the refractive COD remaining in effluent from the first stage. The initial free ammonia concentration in 1st stage varied between 50-90ppm which after passage through the second stage was reduced to 20-45ppm and corresponded to ammonia removal efficiency of 50-65%.

2. ARC trial for NH_3-N reduction

Before the year 2010 ammonical nitrogen reduction was a problem at CETP, as inlet concentration of ammonical nitrogen was higher than 100mg/l. The trial was started in 2010 for reducing ammonical nitrogen as well as COD. Ammonia reducing compound

(ARC) was suggested by Prof. J N Joshi and trial was executed under his guidance. According to his guidance the pH of inlet was raised using lime and ARC was dosed in lamella settler feed tank. After primary treatment, the pH was neutralised using sulphuric acid. Then, effluent was treated in secondary treatment (aeration tanks and settler) and tertiary treatment units (sand filter, dosing tank and settler). In tertiary treatment, hypochlorite and bleaching powder were used. Chlorination trial was carried out using the effluent of the main plant. The results are tabulated below. The costing was calculated considering flow 2.5MLD.

Table 1: Stage Wise Average COD Reduction during ARC Trial

COD mg/l										
Scheme	**pH of lamella**	**Raw**	**Primary**	**%red**	**Secon-dary**	**% red**	**SF**	**Tertiary**	**%red (SC to Tertiary)**	**overall % red**
Primary> secondary> tertiary	10.5	1066	533	49.949	346	67.54	-	261	24.51	75.53
Primary> secondary>SF> tertiary	10.5	1407	901	35.936	414	70.57	335	247	40.249	82.41
Primary> secondary	9	1395	881	36.83	455	67.38	-	-	-	67.37
Main plant ARC trial (5days)	11	1450	1018	29.801	474	67.329	-	-	-	67.32

Table 2: Stage Wise Average NH3-N Reduction during ARC Trial

NH3-N mg/l										
Scheme	**pH of lamella**	**Raw**	**Primary**	**%red**	**Secon-dary**	**%red**	**SF**	**Tertiary**	**%red (SC to Tertiary)**	**overall %red**
Primary> secondary> tertiary	10.5	41	34	17.354	34	16.85	-	5	85.30	87.78
Primary> secondary>SF> tertiary	10.5	38	30	21.184	14	63.49	10	1	94.809	98.10
Primary> secondary	9	36	30	17.66	32	11.90	-	-	-	11.905
Main plant	11	32	25	21.875	5	85.63	-	-	-	85.625

The maximum reduction was achieved when sand filter was use before the tertiary treatment, reduction in COD varied from 80% to 85% and that of NH3-N varied from 95% to 100%.

Table 3: Tertiary Treatment Results when Using Different Chemicals/Gas

Item	COD mg/l			NH3N mg/l		
	Sand filter inlet	Sand filter outlet	Tertiary tret.	Sand filter inlet	Sand filter outlet	Tertiary tret.
Hypo Dosing (500ppm)	421	348	253	14	14	2.00
Bleaching Dosing (50ppm)	412	358	311	7	4	3
Cl_2 gas (500ppm)	Main plant Secondary o/f	488	256	Main plant Secondary o/f	49	21

Item	SS mg/l			Total Cost for Plant scale (2.5 MLD)	Remarks
	Sand filter inlet	Sand filter outlet	Tertiary tret.		
Hypo Dosing (500ppm)	167	74	166	Rs 4 lac	Sludge Production increases by 50-60 %
Bleaching Dosing (50ppm)	191	106	351	Rs 8 lac	Sludge Production increases by 40%
Cl_2 gas (500ppm)	Main plant Secondary o/f	149	126	Rs 41 lac	Higher cost of de-chlorination

The cost of tertiary treatment is very high and additional cost will be there for handling sludge in tertiary treatment. When chlorine gas is used for tertiary treatment, there will be additional cost for de-chlorination.

3. IW Azyme trial for COD reduction

M/s IWA/environment provided IWAzyme (enzyme) for enhancing the performance of aerobic treatment. Series of lab trials were conducted for selecting proper enzyme and operating conditions. IWA/environment suggested two sets of combinations: 1) CETP primary clarifier overflow, 2) CETP primary clarifier overflow and CETP UASB over flow in proportion as maintained in the plant.

CETP primary clarifier overflow was treated in pilot plant maintaining MLSS in between 3500-4500mg/l and detention time 21hrs in aeration tank. The IWAzyme was directly dosed in the aeration tank after 30 minutes of aeration. The results were similar to that of the main plant results.

Mixed flow of CETP UASB out let and CETP primary clarifier overflow was treated in pilot plant maintaining MLSS between 4000-4500mg/l and detention time 19 hrs. The results showed 65-69% reduction in COD at pilot plant and 56-60% reduction in the main plant. There was an additional benefit of 57% reduction in the sludge production. The cost of treatment increased by Rs 0.84 /m^3.

4. Single and two stage aeration using cultures available in lab

CETP is having in its stock some 100 types of cultures extracted from garden soil, NEERI consortium and soil of final outlet discharge point. GIZ team suggested trial where 7 sets of Consortia were prepared using 70 cultures and all the consortia were fed in aeration tank for one month. Initially, the trial was carried out in single stage, where aeration tank had CETP RAS and 7 Consortia as biomass for aerobic treatment, but the results were not satisfactory. Two-stage aeration trial was started after that, where aeration tank of 1st stage contains only CETP RAS and Aeration tank of 2nd stage contained 7 consortium mixture. The detention time in both the tanks was kept 10 hours but we found only 2% more reduction in COD than that in plant. Now GIZ team have suggested to increase the detention time in the second stage aeration tank by 3 times and continue the trial.

5. Moving Bed Bioreactor (MBBR)

Pilot scale trial has been carried out to check the feasibility of attached growth process. The reactor having volume of 14 litres has been used and bio-carriers provided are 15 % of total volume. MLSS maintained are between 4000-4500 mg/l and DO level maintained in the reactor is 2 to 2.5 mg/l through diffused aeration system. The reduction in COD achieved is 55-60 %.

6. Digester

Secondary sludge handling is the main problem of CETP. Primary sludge can be easily thickened to 35% solids through decanter but not the secondary sludge. To handle this secondary sludge trials were started to treat it in digester. Drums of 180lts capacity were used for this purpose. The detention time of sludge was kept 30 days; we found 25.7% reduction in VSS/kg, 16% reduction in TSS/kg and 45% methane in gas. The trial is still going on after modifying the drum. The inlet position of sludge is changed and mixing device is provided in the Reactor to enhance the efficiency of the process. Also, research & development activities are under progress to optimize the aeration time for maximum organic removal, two-stage aeration using bio towers, ozonation as tertiary treatment and post aeration for the anaerobic treatment for better COD removal.

We have also practiced the stream segregation for the high strength wastewater i.e. having high COD & high TDS effluent. This effluent is being treated through chemical oxidation i.e. FACCO. Due to regeneration problem in FACCO treatment, we have now proposed Multiple Effect Evaporation for such type of stream which contains very high amount of refractory organics which are difficult to biodegrade.

Strategies for Sustainable Hydrocarbon Processing

Dr. M. P. Sukumaran Nair*

INTRODUCTION

Petroleum refining and associated downstream hydrocarbon processing operations are challenged on the one hand by tightening product specifications and on the other by shifting crude quality, forcing an increased proportion of heavy and sour crudes. Regulatory specifications for products as well as process effluents have been getting indirectly stringent over the years necessitating utmost optimization at every stage in refining operations while still retaining the industry commitment to economically provide hydrocarbon based fuel and feedstock and meet the increasing needs of a growing global population. All-around awareness of environmental degradation caused by industrial activities in the hydrocarbon processing sector on account of greenhouse gas emissions, stratospheric ozone depletion, acid rain and acidification, eutrophication, soil contamination, technological hazards, chemical mists and fog, all with potential damage to human beings, is indeed a topic of much discussions at both national as well as international fora.

Environmental considerations, therefore, assume great importance in hydrocarbon processing operations which generate a large quantum of effluents and emissions capable of degrading the environment. Besides meeting physical targets of production adhering to quality and safety stipulations, industry operators are also responsible for effective by tackling environmental issues related to the production process and for avoiding damage to the community. An effective environmental management perspective must addresses the numerous issues relating to pollution control, ensures safety and thus maintains sustainability in the industry. The clean development initiatives in hydrocarbon industries can be a major instrument in this endeavor.

The growth of hydrocarbon processing has hitherto been guided mostly by the necessity of increasing production at lower costs leading to serious environmental degradation of water resources, soil and air around processing plants. Worldwide, the focus of pollution control in the industry has shifted from the end of pipe treatment to source reduction, avoiding pollution, employing clean technology and promoting sustainable development. Hence, it has become imperative that environmental considerations play a substantive role in the future development of the industry especially at a time when more and more such industrial activities are being undertaken in developing countries.

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Recent studies in different parts of the world have focused attention on this issue with the objective of identifying key factors in environmental protection under different industrial processes, assessing to what extent national and international norms or guidelines regarding pollution control and environmental management are being implemented, understanding the problems encountered and exploring the reasons for non-compliance of various guidelines. On the basis of the studies efforts have been made to develop environmental guidelines and to adopt cleaner technologies that foster development with minimal degradation of the environment.

STATUS OF ENVIRONMENTAL MANAGEMENT

Environmental pressures have become a major driving force in the development of advanced process technologies, catalysts, retrofits and revamps of old installations. Today, most hydrocarbon processing units, be it in the developed or developing countries, have specific environmental policies and their emissions, effluents and waste disposal are guided by the stipulations laid down by regulatory authorities. New plants that are being built have modern technologies where considerable integration has taken place at the inception stage itself to see that pollution prevention is a part of the process design itself. Older unitsare now operated with additionally built state-of-the-art pollution control facilities. Effective control facilities exist in most processing units and they are being operated with due diligence. The stipulations of the pollution control and environmental protection agencies are also within the achievable limits of available technology. Still mistakes, sometimes, occur on account of accidents.

Several national as well as international standards covering a wide range of parameters have been developed regarding emissions and effluents from hydrocarbon industries. These include volatile organic chemicals (VOC), suspended solids, oil mist and chemical and biological oxygen demands in effluent streams, particulate matter and nitrogen oxides, sulphur oxides and carbon monoxide in exhaust streams. Levels of toxic compounds, such as benzene, heavy metals, other reactive organic compounds and biological pollutants, etc. are also monitored in specific cases.

A typical refining installation may emit around a 0.1 to 3 kg of particulate matter; 0.2 to 6 kg of sulphur oxides, SOx (0.1 kg with Claus sulfur recovery unit), 0.06 to 0.5 kg of NOx; and 0. 75 to 6 gram of BTX (benzene, toluene, xylene) for every ton of crude processed.

Of this, about 0.14g of benzene, 0.55 g of toluene, and 1.8 g of xylene may be released per ton of crude processed. VOC emissions depend upon the technology used for production, emission control mechanisms available, equipment maintenance, and climate conditions and may be in the range of 0.5 to 6 kg per tonne of crude processed.

Clean fuel initiative in industry constitutes a major step towards attaining environmental sustainability. Mandated by the US EPA in 1972, a gradual phase-out of leaded gasoline was achieved in most countries of the world on account of public health concerns. Again sulphur removal from diesel fuel by the DHDS process, initially to lower levels and thereafter to ultra low sulphur level (ULSD), and use of alternative and renewable fuels such as ethanol, methanol and bio-diesel are serious efforts in this direction. The underlining factor in these developments to improve its environment friendliness lies in the success of the industry to innovate and develop feasible technologies.

CLEAN TECHNOLOGIES

Distillation, catalytic reforming, hydrotreating, isomerisation, catalytic cracking, hydrocracking, alkylation and thermal operations are among major processes involved in the refining industry. Except distillation and thermal operations all other processes employ catalysts. Current developments in environmental chemistry and hydrocarbon engineering have helped industry operators to reduce effluent generation at source. Very often, treatment of pollutants emanating from industrial operations is linked to the plant's processing technologies. Over the years, the specific consumption of raw materials and energy for manufactured products has registered continuous improvement with the adoption of efficient technologies and best operating practices at the plant level. This has contributed to achieving better environmental standards through reduction in emissions, effluents and solid waste per tonne of product manufactured.

Further improvements towards better environmental quality may require major design changes involving additional investments or going on for newly proven and commercialized processes. This is a costly option and hence limited unless it brings out increased productivity, lower energy consumption, etc. In the case of products having high water intensity, there is an economic benefit in reusing treated effluents so that water conservation is achieved.

The start-up and shut down of plants may lead to increased levels of pollution compared to their normal operations. Hence, most plants are equipped with specific provisions to take care of such situations.

Most of the pollution prevention methods implemented in industries follow prescriptive approaches which follow standardized procedures built around questionnaires and checklists. The new approach is to adopt a more descriptive approach in which process operators are challenged to attack pollution problems and devise new and innovative ways for solving them. Managements undertake substantial efforts to develop green belts and maintain greenery around these plants so as to reduce the impact of greenhouse gases. This is an important step in the direction of sustainable environmental control.

An establishment of ISO 14000 Environment Management Systems and a corporate environmental set-up for regular monitoring and control is another major step in the area of environmental protection. These systems are intended for continuous improvement of the existing operations from the environmental angle. Certain industries have adopted zero effluent approach incorporating total recycling and reuse of effluents back to process. This is still a working process. Most process operators use industry-codified Best Available Techniques (BAT) for environmental control to meet both effluent specific and product specific standards.

In India, as in many other developing countries, systems are employed to the extent of controlling and reducing pollution from plants within the limits set by statutory authorities, such as the Pollution Control Boards (PCB). Operating units do not make further efforts to reduce pollution beyond the prescribed limits primarily due to lack of incentives to make additional investments.

Most hydrocarbon processing operations emit large quantities of carbon dioxide (CO2), a major greenhouse gas. No emission standards for carbon dioxide are prescribed by statutory bodies. Attempt to reduce greenhouse gas emissions to tackle climate change may bring in specific limits for carbon dioxide emissions and effective measures for sequestration in future.

Every processing unit imposes a certain environmental burden on the local environment and its impact categories are acidity, global warming, human health effects, ozone depletion, photochemical smog, aquatic oxygen demand and eco-toxicity to aquatic life, etc. A parametric assessment of the contribution of each of these components can be used to compare yearly performances of plants.

The necessity of maintaining a safe work environment for employees and the neighboring community is well recognized. For this purpose, extensive hazard and risk analysis using techniques such as Hazard Operability (HAZOP) Studies and Quantitative Risk Assessment (QRA) are conducted based on which safe systems, work practices and risk reduction measures are adopted. The environmental management plans of production units are capable of mitigating risks from most expected crisis situations barring those from nightmare incidents such as earthquakes on sabotage.

Public information regarding the environmental consequences of these plants is one of the important measures. The communities associated with these units have a right to know the environmental risk to which they are subjected.

In most countries, it is now mandatory that an Environment Impact Assessment (EIA) to be done prior to implementation of a project having large-scale environmental consequences. A proper Environment Management Plan (EMP) should also be in place before the unit starts operating.

ENVIRONMENTAL CHALLENGES

Climate change across the world, depletion of the ozone layer in the outer atmosphere, loss of biodiversity elements such as migratory species and important genetic resources, widespread degradation of land, urban air, forests and natural waters and marine ecosystems, and an accumulation of persistent organic pollutants in nature are major global environmental concerns. These issues have an impact that transcend national boundaries and hence requires global solutions. There are over 200 international enactments governing environmental issues and, together with currently available technology and best practices, further mitigation of degradation is possible. The far-reaching measures to combat the effect of greenhouse gases agreed to the Kyoto Protocol is getting thwarted by many developed nations such as the US and Australia. In India, we have framed a comprehensive auto fuel policy that considers an availability and security of supplies, vehicle technology, cost-effective emission reduction, fiscal measures and institutional means to bring about progressive improvements by reducing vehicular emissions. The fuel cell as a power source is becoming a viable alternative to the internal combustion engine with lower environmental impacts. Thus, concerted efforts are required both at the national and international level to stop further degradation and undo the damage already done. National environment policies should foster efforts for sustaining environmental health of the people and shall call for a discrete assessment of pollutants entering the natural environment from human interventions in terms of their toxicity, persistence, mobility, bio-accumulation and methods available for source reduction and control mechanisms.

CONSIDER ALTERNATIVES

More and more industries are switching over to environment friendly raw material and energy resources in order to improve sustainability.

The use of natural gas (predominantly methane CH4), a relatively benign raw material and energy source as compared with other petroleum feedstock like naphtha, fuel oil and coal to produce ammonia, the basic building block of the nitrogenous fertilizer industry indicates a shift to pollution reduction efforts. This route has led to reduced CO2 emissions and lowered waste generation and energy intensity.

The use of water in place of organic solvents to replace volatile organic chemicals (VOCs) as reaction medium in organic synthesis is another important innovation. Use of ethylene dichloride (EDC) for extraction of food items has been replaced by n-Hexane.

Manufacture of sulphuric acid from pyrite roasting has a lesser impact than using elemental sulphur. Recycling of metals, recovery of metals from spent catalysts, sludge from metallurgical operations are intended to reduce the impact of large-scale mining of metals and minerals.

Begasse from sugar industry is used as a raw material for the paper industry in place of wood pulp. Treated softwood is extensively used in place of hardwoods for furniture. Several oxidation reactions involving in air are being replaced with gaseous oxygen to ward off formation of toxic nitrogen oxides. Use of new generation polymers and plastics in place of metal in highly corrosive applications, are intended to reduce the environmental burden.The construction industry is being increasingly encouraged to use locally available materials to replace steel, glass, wood, and cement.

Use of hydrogen in place of fossil fuels in engines is at an advanced research stage and once technically and economically feasible, it offers an environment friendly option for transportation. Natural zeolites find extensive applications in place of alkyl benzene sulfonates (ABS) as detergents. Power generation using vacuum residue from crude refining operations is a sustainable option to dispose of the unmarketable end product. The residue after improved crude utilization processes such as hydro cracking are highly viscous, heavy, difficult to handle and as such are not marketable. The quantity of residue from refineries varies from 20 to 40 percent of the throughput depending on the crude characteristics and secondary process employed. Refiners are looking for alternative residue utilization strategies for producing lighter, high-value products to help them remain competitive in a market where the demand for light oil products is steadily increasing.

Several biofuels are being used in the automotive industry. Ethanol and bio-diesel have emerged as reasonable alternatives to conventional petroleum fuels. These are of agricultural origin and can be easily blended with hydrocarbon fuels upto 50 percent blends and can be used in existing vehicles without any modifications. Biofuels are renewable resources, non-toxic and bio-degradable and have reduced inflammability and their performance is also superior. Ethanol-blended gasoline has become a commonplace fuel in many countries. Ethanol, largely available as a byproduct of the sugar industry, is non-toxic and is thus environment friendly causing no harm to soil, waterbodies and public health. Being an oxygenated fuel, ethanol enhances the combustion of gasoline and effectively lowers emission rates from engines.

The use of natural fibers like coir, jute, etc impose the least burden on the environment vis-à-vis other products for similar applications such as nylon, polyester, poly ethylene, etc. Coir geo-textiles find extensive application in preventing landslides.

The biotechnology products reduce the intensity of normal cropping in terms of inputs like fertilizer, land, water and have better resistance to adversities like pest infection. Several BT products reduce environmental footprints.

Recycling of paper and use of natural polymers in place of plastics are greener options. Currently, 150 million tons of plastics are produced a year from fossil fuels all around the world. Plastic products have gained universal acceptance in areas like transportation, construction, medical and entertainment. There is a growing demand for biodegradable plastics as a solution to global environmental and waste management problems.

Research on biodegradable plastics and polymers has been carried out worldwide with the aim of achieving a balance between human activities and the natural environment. Ideal biodegradable plastics are defined as materials, which are completely degraded to carbon dioxide and water by the action of microorganisms. The resources of biodegradable plastics and polymers are mainly classified into bio-synthetic polymers such as poly-hydroxyalkanoic acid, plant poly-saccharides such as cellulose, starch and xanthan, and synthetic polymers such as polylactic acid, poly-caprolactone and poly-aspartic acid. Biodegradable plastics are expected to replace plastics derived from petroleum products in agriculture and fisheries, construction materials and toy manufacturing where recovery and reuse are difficult.

GREEN MANUFACTURING

Green Manufacturing (GM) aims to prevent pollution and save material and energy through innovation and development of new knowledge that reduces or eliminates environmental damage during various stages such as design, manufacture, and application of products or processes. Apart from use of benign materials, changing technologies for processing also add to environment friendliness in manufacturing industries. Existing processes also have to undergo sea changes to become environment friendly.

Improved catalysts increase conversion and yields, reduce recirculation and increase output. The best illustration is the development of ruthenium catalyst in place of the conventional iron catalyst for the ammonia reaction. This helped improve conversion threefold, reduce the size of the plant and rendered possible higher plant capacities. In situ generation and consumption of hazardous and toxic intermediates, thus avoiding storage and transport, is another option. An example is the manufacture of methyl isocyanate and its immediate conversion to pesticides without going in for storage, a lesson we have learnt from Bhopal.

Other sustainable improvements in reaction engineering include Carbonylation using dimethyl carbonate instead of phosgene or carbon mono oxide, use of solid catalysts to minimize waste, attempt to manufacture petrochemicals from renewable sources, produce alpha olefins from fatty acids rather than petroleum products, avoiding use of toxic acids, catalysts, solvents in all applications and going for photo-catalyzed reactions using natural dyes as catalysts instead of heavy metals. Another development is the low analysis fertilizers, which can be made with a nutrient content sufficient only to meet the demand of the plants, so that leaching to the environment is minimal.

The development of the membrane cell process for caustic soda in place of mercury cells is an example. This has helped the industry to ward off mercury contamination, as in the byproduct, hydrogen, being used for food grade applications. Membrane separation processes and pressure swing absorption have come of age for physical separation of gases in place of chemical absorption and regeneration.

The harshness of chemical reactions as depicted by elevated temperature, increased concentration, high pressures, large reactor volumes, corrosion tendencies and flammability characteristics are being brought down considerably through technological innovation. Nowadays, several reactions are being carried out under lower temperatures and pressure and concentration with improved catalytic efficiencies. The best example is again from the fertilizer industry where ammonia synthesized of 350 atmospheres pressure two decades ago, has been lowered down to operate at as low as 80 atmospheres. The potential for recycling and reuse within are being exploited considerably and modern plants are built with such integrated facilities.

PROMOTE INTEGRATED CHEMICAL COMPLEXES

Refineries, fertilizer, power and petrochemical plants are themselves major investment and high technology. Technology brings in lot of scope for exploiting the synergy within these units, which could play a major role in improving the bottom line of current operations of these units. Integration of refineries, fertilizer and petrochemical plants, and power generation units at the planning phase itself in integrated complexes could drastically reduce emission and other pollutants and ensure optimized operation.

REVIEW EXISTING CONTROL LIMITS FOR POLLUTANTS

The present standards for discharge of effluents from industrial units are governed by technological limits attainable through application of available technologies for abatement and control and are not based on their long-term health effects. Revised standards based on the health impacts of each of the pollutants may be developed incorporating advancements in this area.

BEYOND COMPLIANCE OF STATUTORY STIPULATIONS

In process plants systems are employed to the extent of controlling and reducing pollution from plants within the limits set by statutory authorities. The units do not put in further efforts for reducing pollution beyond the limits prescribed by pollution control boards (PCB) in the interest of public health. This is primarily due to lack of incentives to encourage additional investment on improved technology. Hence, industrial units should be encouraged to go beyond compliance and become more environment friendly.

POTENTIAL OF ENVIRONMENTAL BIOTECHNOLOGY

Environmental biotechnology employs living organisms –flora and fauna- engineered to exhibit specific traits in order to identify, control or prevent pollution. This technology has been applied to clean-up hazardous waste sites more efficiently than conventional methods, thereby reducing the need for incineration or extraction-based methodologies. Bio-remediation has been applied to the clean-up of numerous varieties of pollutants, including oil spills, heavy metals, persistent organic pollutants, explosives, sewage and industrial waste. In tropical climates, biological processes for pollution control have an edge over chemical processes and are more efficient. Modern developments such as recombinant and genetically engineered organisms find extensive application in biological processes for pollution control and bioremediation.

REDUCE EMISSION OF GHGs

Financial incentives should be made available to those endeavoring voluntarily reduce to greenhouse gases resulting in climate change. The extension of natural gas pipelines, harnessing clean coal technologies, integrated gasification of coal and biomass with combined cycles for power generation shall be encouraged.

REDUCE WATER INTENSITY

Hydrocarbon processing is a highly water-intensive industry. It takes approximately 1-2 barrels of fresh water to refine a barrel of crude. Availability of good quality water for the community and industry is going to be a major problem in the coming years. In order to address the issue of availability of adequate water for industries, recycling and reuse to the extent possible may be resorted to. Membrane technologies have come of age and are cost-effective these days. Most units rely on ion exchange and reverse osmosis to purify water. Recycling of municipal waste water after adequate level of treatment offers large scope for mitigating industrial demands for water, and helps improve environmental sanitation around the area.

DEVELOP POLLUTION INVENTORY DATABASE

The policy option should be to strive to develop a national level pollution inventory database and ensure that pollutants on reduced over a period of time during the development process. Environmental regulatory authorities in developing countries may thus be encouraged to become solution providers to industry rather than being mere policing agents.

HAZARDOUS WASTE DISPOSAL

Management of hazardous waste materials generated by industries has become a major concern of plant operators. Hazardous waste may be solid, semi-solid or non-aqueous liquids which, because of their quantity, concentration or characteristics, may significantly contribute to an increase in mortality or irreversible damage. Left uncared or improperly treated, stored, transported and disposed of, they are capable of posing a potential hazard to human health and the neighboring environment. Waste is classified as hazardous if it exhibits, whether alone or in contact with other wastes or substances, characteristics such as corrosivity, reactivity, ignitability, toxicity, acute toxicity or infectious property. These substances either created as by-products of industry or as residues of the process adopted are highly toxic and are capable of causing irreversible damage to the environment. Most industries have identified such materials and are subsequently classified. Accordingly, a lot of hazardous waste is generated in countries as a result of several industrial operations and there are imports too for recovery of valuables, etc. Disposal of such waste is yet to gain the desired importance despite legislation in this regard for over 10 years. Many industrial districts are yet to identify disposal sites. Determined efforts are necessary on the part of local Governments to put up facilities for treatment within a definite time frame.

EMERGENCY PLANNING FOR DISASTER MITIGATION

Local level emergency planning for disaster preparedness in case of natural calamities and man-made disasters is important. Effective mechanisms for mitigation of hazards should be developed under the district administration. These programmes may be coordinated on the lines of the Awareness and Preparedness for Emergencies at Local Level (APELL) project of the United Nations Environment Programme (UNEP).

KEY ISSUES

Thus, the key issues in environmental management in processing industries may be identified as pollution from solid waste resulting in contamination of land space, liquid effluents endangering streams and groundwater resources, and gaseous emissions degrading the quality of atmospheric air. Risk to life and property from operational incidents may emanate in the neighborhood of these units due to faulty storage, handling, transport and use of large quantities of inflammable and hazardous chemicals and hydrocarbons.

Generally, there is a good deal of compliance by all units with the standards prescribed for the discharge of effluents. Often, units are committed to attain the norms for various parameters as stipulated by Pollution Control Boards. Units even attempt to do if there are sufficient economic incentives for making the required additional investments.

ADDRESSING CHALLENGES: NATIONAL ENVIRONMENT POLICY

The important problems encountered in environmental management in the CPI are lack of:

1. Incentive for continuous improvement in the direction of pollution reduction beyond the compliance limits stipulated by the Pollution Control Boards;
2. Integration of environmental concerns into the core of the business strategy; and
3. Sufficient transparency with regard to environmental information.

To effectively address the above problems and foster development, an apex level environmental policy incorporating clean development strategies with the following elements will be required. Systems and practices are to be in place to identify and assess potential environmental impacts at the conception and planning stage itself. Adequate steps need to be taken to mitigate impacts during execution of the project and later throughout the operations and also to monitor and mitigate impacts even after the project's decommissioning and site remediation.

1. Role of Top Management

The first and foremost guiding principle of an environmental policy facilitating growth of the industry is to ensure the unstinting commitment, involvement and action oriented approach of the top management of the organization in achieving the set environmental goals.

2. Environmental Policy Statement

Top management shall codify their environmental commitment, values and perceptions in a documented policy. The policy shall be relevant to its activities, products, and services and taking into account its implications on the different stakeholders. Attempts for improving energy efficiency, resource productivity and use of renewable source of energy and raw material need special mention in the policy document.

3. Environment, Health, Safety (EHS) Vision Statement

Every unit shall have an environment, health and safety vision statement depending upon the nature and scale of its operation and specifying its current thinking and aspirations for the future. They shall adopt a national pollution prevention policy that encourages source reduction and environmentally sound recycling as a first option and also recognizes safe treatment, storage and disposal practices as important components of an overall environment protection strategy.

4. Environmental Targets

The environmental targets i.e., the qualitative and quantitative changes that are to be brought about to bring in more environment friendliness in the industry and acceptance to the community around are to be clearly set. Steps that are envisaged for minimizing environmental impacts, reducing emissions of toxic gases and those causing global warming and improving the current levels of employee health, safety and pollution prevention are to be specified. The target must also address achieving zero accidents at workplaces, reducing incidents of work related diseases and bringing about overall reduction of the risk exposure to the employees as well as the community around. It focuses attention on achieving sustainable development and eco-efficiency as a new business perspective for the industry through production and innovation integrated environmental protection, responsible product stewardship and aiming at total quality improvement. It is desirable that the environmental friendliness of the industry shall improve year-by-year through implementation of a guided approach and action plan. For this purpose, existing environmental burden (EB) imposed by these units will have to be quantified by considering suitable indices for every environmental aspect. A lifecycle analysis (LCA) based approach from conception and production to full scale utilization and disposal of the product may be used to determine the overall environment burden.

5. Control Strategies

The policy shall provide for the use of legal, financial and social instruments, which influence the behavior of companies, citizens, public bodies and authorities for achieving the objectives of the policy. Existing and innovative control mechanisms such as statutory provisions, stipulations of the various regulatory bodies may be used. Industry may be asked to go for the currently best available technology for pollution abatement. During the interim phase, strategy of monitoring comparison with set standards and penal action wherever required shall continue. Plants shall be operated to standards that will comply with the requirements of appropriate national and international legislation and codes of practice. The government shall formulate country-specific Best Available Techniques (BATs) for the industry to facilitate continuous improvement in environmental management. Technically and economically feasible regulatory as well as non-regulatory measures shall also be suggested to improve environmental management in hydrocarbon processing operations. Fiscal incentives may be provided to encourage adoption of technologies that reduce pollution.

6. Risk Management

It is necessary that the management shall ensure that potential health, safety, and environmental risks associated with the activities are assessed early to minimize and manage adverse effects and to identify opportunities for improvement. A workable Disaster Preparedness and Emergency Management Plan (DPEMP) shall be kept ready to mitigate any such situation in the unlikely event of its occurrence.

7. Staff Training

Necessary and state-of–the-art training may be given to the concerned people responsible for environmental management. This should include keeping them abreast of the new developments, technologies and practical tools, accident investigation, environmental impact prediction, selecting appropriate protective equipment, implementing emergency response plans as and when necessary, and so on. They may be trained to learn from previous incidents and similar experiences. They must be made conversant with the corporate environmental management systems and the proposed action plan for its implementation .In short, necessary capabilities must be available in-house with all organizations to tackle probable emergency situations that are likely to arise.

8. Monitoring

The policy shall call for regular and meticulous environmental performance monitoring to keep track of the environmental burden imposed by the company and watch the direction of its progressing trends. Quantitative as well as qualitative approaches may be used for this purpose. Emissions, waste streams, hazardous waste, disturbance, resource depletion, etc. shall be addressed accordingly. Commitments towards targets for responsible care and social responsibility may also have to be assessed.

The current operations shall be regularly and systematically assessed for the purpose both of identifying and correcting any element which may put human beings, real property or the natural environment at risk of nuisance or damage and of establishing a basis of safety-related improvements of processes and products. Any new process and product as well as any new information related to existing processes and products should be thoroughly analyzed with regard to their health, safety and environmental implications.

The concerned authorities shall be kept well informed of the operations and of their health, safety and environmental implications. Any incident entailing a risk of environmental disturbances or of conflict with existing regulations should be promptly reported to the proper authority.

9. Public Information

Necessary provision may be made for sharing information on environmental safety and health with the public and it should be incorporated in the policy. The policy shall provide for involvement of the community and its working with active environmental groups in the region in bettering the environmental situation and thereby enhancing public perception of the industry.

10. Annual Reports

The policy shall call for Annual Environmental Status Reports (AESR) along with the financial performance reports. Such reports are now available from many operators around the world. The feedback on these reports from the concerned stakeholders may be used for continued improvement of the existing systems. The policy document shall be integrated with the national environmental plan of the country.

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Debating the National Water Framework Law

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INTRODUCTION

The Draft National Water Framework Law, in short, NWFL (MOWR, 2013) as it emerged from a Committee I chaired was a draft for discussion. It was a base for comment for, as it says, in a federal society these are contentious issues but need resolution. So when Phillipe Cullet wrote on it (Phillipe Cullet, 2013) I looked forward to reading it. He has in his piece interesting perspectives but nothing on the Draft National Water Framework Law based on the material or wording of the Draft Law. We take his arguments one by one, quote them and similarly the Framework Draft to show this and argue that the debate is yet to come. This is, therefore, a factual piece and not on the intrinsic merits of the Law since a discussion of that has to wait until it is commented upon after being read.

DECENTRALISATION

P. Cullet writes "the two new bills seem to be informed by a completely different perspective that is premised on strengthening the role and powers of the Central Government at the expense of the states and a fortiori districts, blocks, municipalities, panchayats, ward sabhas and gram sabhas."(p.57).

As the Foreword to the Framework Law by this author states, " In an initial draft Shri Mohan Kumar, then Additional Secretary, MOWR, used a very convenient expression: 'Appropriate Government'. The Framework is meant to provide the larger structure for organizing the support mechanisms to States and communities in their governing institutions at the levels that matter, the Local Government, CBOs (Community Based Organisations), the Management of ponds, water bodies, watersheds, aquifers, and river basins. These support mechanisms can be critical for the Appropriate Government. Cutting edge frontier technology in water delivery and development projects has to be developed at home and accessed in the World and made available. Working Best Practices must be known and diffused. Development and applications of success stories will require data and information support. The Framework attempts to set up the systems to aid the State Governments, Local Bodies and the Appropriate Government in these support mechanisms. (NWFL, 2013, p.ii)."

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Nothing can be more explicit than this statement that the Framework Law gives centrality to communities in their governing institutions at the levels that matter-the Local Governments and community-based institutions for the water sector. Systems at higher levels are visualized to support these institutions. CBOs are defined as follows (NWFL, 2013, Ch. 1,Sec.2(v) p.51):

"Community based institutions means Panchayati Raj Institutions, Water Users Associations and other local governing bodies;" Cullet interestingly wants these bodies to be more sharply defined in their functioning in a constitutional system which permits diversity. This is a problem in his comments as a whole. Details which in any legislation would come in Rules and are of an operative nature are placed as requirements in a National legislation of a Framework character.

The approach giving primacy to Local Governments is reiterated in the Draft Framework Law a number of times. Therefore, Chapter 1, Section 2(i) states; " Appropriate Government‖ means in relation to interstate rivers and river valleys, the Central Government and in relation to rivers confined to the territory of a State, the State Government; and as defined in the concerned legislation devolving powers to local bodies (NWFL,2013, p.51)." Further "Local Authorities and the appropriate Government shall take all measures to plan and manage water resources equitably, sustainably, and in a socially just manner". (NFWL, Chapter 2, Section 3(2), p.54), and again, " The planning, management and regulation of water resources shall be carried out by the appropriate Local Authorities and the appropriate Government in a manner that is transparent, accountable and participatory."(Ibid., Section 3(3), p.54).

Further, and this even Cullet recognizes, "the extraction of groundwater in any manner in any area shall be regulated through community based institutions with due regard to the hydro-geological and ecological characteristics and features of the aquifer as a whole.

Provided that such users and community based institutions will be empowered to take information based decisions based on aquifer information and extraction data shared with them (NFWL, 2013, Chapter 4, section 12,(4),p.60). Also, "the appropriate Government and local Authority shall take all possible measures to protect and improve the quality of groundwater, including measures for prevention of pollution and for remediation from groundwater contamination." And again, "the appropriate Government and local Authority shall ensure planning and implementation of necessary safeguards to protect the quality of groundwater while giving licences for mining and industrial activities (Ibid. Section 12(8) and (9), p.61).

More generally, "Local governing bodies like Panchayats, Municipalities, Corporations, etc., and Water Users Associations, wherever applicable, shall be empowered and involved in planning and management of the projects."(NFWL, 2013, Chapter 4,Section 10(5), p.58).

In fact, it would be for the first time that such explicit functions will be legally legislated for the appropriate government at the local level in India and powers backed by law if the legislation is enacted .In the ex opere operata comments which P. Cullet makes it would have been nice if at least some of these points so explicitly introduced in the Draft legislation were read and referred to.

WATER AS A MINIMUM NEED

Cullet decides "On the whole, the Framework Bill seems to be most concerned about a twin agenda of centralization and commercialization."(p.58). Re. commercialization the Draft says:

Pre-emptive needs means the needs for water, such as for drinking water, sanitation and other needs, as may be prescribed, which have to be accorded highest priority and must be met before any other need;"(NFWL, 2013, Ch.1,Sec.2, (xviii), p.51)

1. Every individual has a right to a minimum quantity of potable water for essential health and hygiene and within easy reach of the household.
2. The minimum quantity of potable water shall be prescribed by the appropriate Government after expert examination and public consultation. Provided that the minimum quantity of potable water shall not be less than 25 litres per capita per day.
3. The state's responsibility for ensuring people's right to water shall remain despite corporatisation or privatisation of water services and the privatisation of the service, where considered necessary and appropriate, shall be subject to this provision. (NWFL, 2013, Ch.4)

The Falkenmark Index is there and yet the minimum need for human consumption is a question. For the human consumption aspect a globally accepted norm does not exist.[1]

In developing countries, the question of water for animals becomes a vexed issue and the Government of India references Cullet gives are select programme features and not minimum needs in a universal sense. In fact, the earlier minimum needs plans only

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1. For a discussion of this aspect in the FAO/UNESCO framework see Yoginder. K. Alagh, More on MOST, UNESCO, 2002,pp.

talked about the availability of a drinking water source and quantities of flows were not stated. In fact, apart from exceptions like Bengaluru, measured quantities of water deliveries were not known in India. Having chaired the Task Force which defined India's Poverty Line which continues upto today since the Tendulkar Committee did not set down a new criteria but decided that the Alagh Urban Poverty Line should be the National Poverty Line we have been asking for a new definition since the Nineties of the last century, This has not been done.

However, practical problems cannot await resolution of these issues. We followed the approach operationalized in the Food Security legislation and described by experts like Abhijit Sen and others like us. The Food Security legislation has the approach of keeping the norm low but coverage universal. The low norm is a minima which can and is, expected to be exceeded in most cases. Thus, if the minimum norm directs a certain minimum quantity of grain to be delivered at a minimal price, the rest is expected to be made up by the State Governments and from the savings achieved by poor households when some grain is delivered free. The pregnant woman is not given a glass of milk and the girl child an egg, but the legislation is a step in that direction. The 25 lpcd is to be enforced by law even if I am at 2000 meters above sea level in the Himalayas or in the desert. It is a minimum. When the Aam Admi Party exceeds it the NFWL is not unhappy.

The NWFL makes the minimum aspect clear as the above quotes show.

Phillipe Cullete has a number of interesting points on the environment and other issues. They are well taken. In no case does he extend the courtesy of quoting the Framework he is critical of in any detail. Hence they are of interest but not in this debate. That debate is yet to take place.

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