Wastewater Production, Treatment and Use in Nepal

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Abstract

This country paper attempts to present the state of wastewater production, management and use in Nepal. While the paper attempts to assessing the trend of wastewater production and in the country, it also presents the current state of policy, technology and management practices and the institutional arrangements in addressing the development and management of infrastructure and services on wastewater management and the environmental, health and livelihood consequences emerging from wastewater production and use in the country. Specific focus has been made on the agricultural use of wastewater, the impacts on the agricultural production environment and the people using wastewater in production of crops. In presenting the use of wastewater in agriculture focus has been made on the existing practices of wastewater use by the people. The paper ends with an analysis on the state of knowledge in the country relating to safe use of wastewater and assessment of the capacity building needs of the relevant institutions concerned with the management and use of wastewater. The analysis in the paper clearly identifies that management of wastewater in the country is driven by the notion of wastewater as ‘environmental nuisance’ rather than a ‘resource’ with potential for safe application in agriculture and non-agricultural uses. This notion was identified to be driven due to prevalence of sectoral and disciplinary approaches in water sector development. The water sector policy environment in the counry, legislation and regulatory provisions, in general, were found favoring promotion of safe use of wastewater while gaps were identified at the institutional arrangements and implementation levels. The gap in the implementation level was noted in terms of separation of use of wastewater from design, development and management of wastewater system and services. The analysis also clearly revealed that large and centralized infrastructure and services and technology solutions would not be insufficient to address the wastewater problem in the country. The opportunity however lies in considering wastewater as a resource and promoting safe use of wastewater as means to ensuring and adding to water security at the local level. The knowledge system in the country and research and development on wastewater system, practices and safe use were noted to be largely deficient.

1. Country Context

Nepal is a landlocked mountainous country in South Asia, located between latitudes 26^{o}22’N to 30^{o}27’N and longitudes 80^{o}04’E to 88^{o}12’E, and bordered by China to the north and India to the south, east and west. With a total land area of 147,181 km^{2}, the country is characterized by diverse topography, geology and climate creating opportunity and constraints for diverse land uses and livelihood patterns. Nepal is predominantly mountainous with 77% of the land area under hills and mountains and only 23% of the area is flat, called Terai, located along the southern border. The elevation ranges from 64 m above sea level to 8,848 m at the summit of Mount Everest, within a span of 200 km.

The total population of the country based on the population census of 2011 is 26.62 million which is essentially multiethnic and multilingual. Nepal's economy is largely based on agriculture, which contributes to nearly 40% of GDP and provides employment to two-thirds of the population. The cultivated area of the country is 2.642 million ha, of which 1.766 million has is potentially irrigable. At present nearly 42% of the cultivated area has irrigation facility of some kind but only 17% of cultivated area has access to year round irrigation. Administratively the country is divided into five development regions and 75 districts. The districts are considered the key units for development planning and delivery of administration and support services. At the local level Village Development Committees (VDCs) and Municipalities are responsible for delivering the governance and support services in the rural and urban areas. There are 99 Municipalities and 3754 VDCs in the country. Poverty is widely prevalent in the country with 25.4% of the population below poverty line considering poverty line of 1 US$ per capita per day (NPC, 2010).

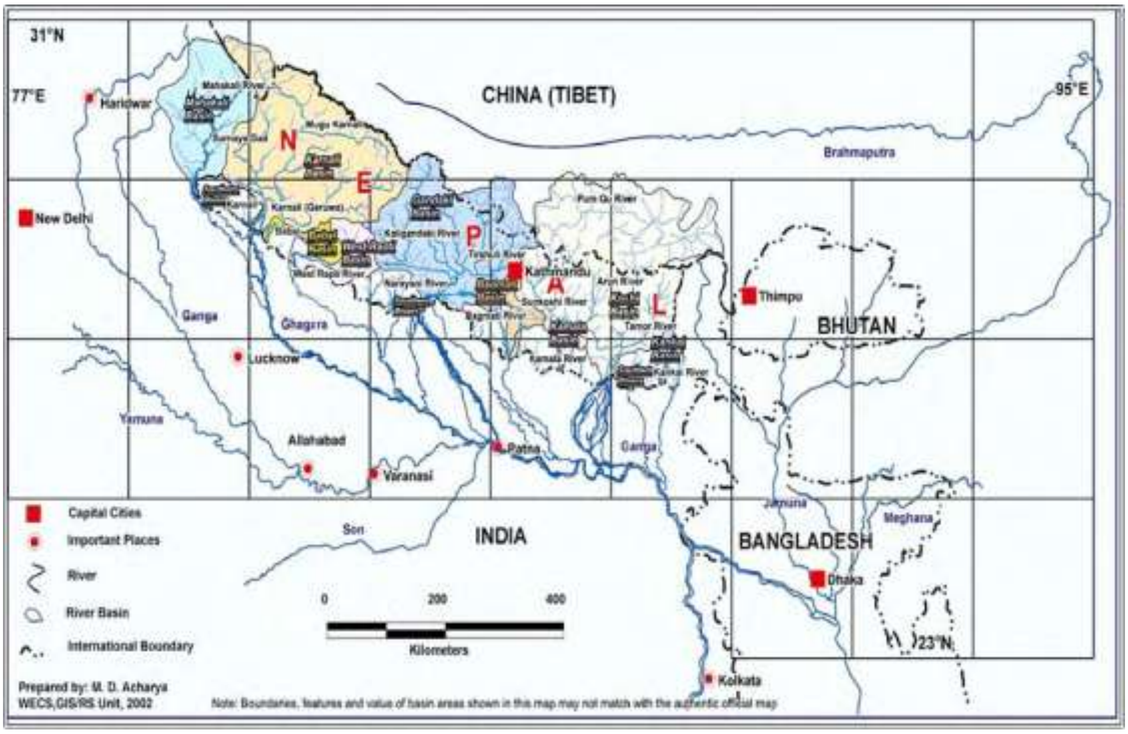

Figure 1: Geographical Settings of Nepal

2. Water Resources Availability and Use

Water is the largest and most valuable natural resource in Nepal. The major sources of water are rainfall, glaciers, rivers and groundwater which support wide ranging social, economic and environmental needs in the country. Of these different forms of water resources in the country, rivers are the most important running surface sources water in terms of volume and potential for utilization in wide ranging economic activities, involving irrigation, hydropower generation, water supply and sanitation and navigation. There are over 6,000 rivers in the country with an estimated total length of more than 45,000 km (CBS, 1998). All major rivers in the country, especially those originating from upper and middle Himalayan regions are fed from snowmelts or groundwater and hence they are perennial. The rivers originating from lower Shiwalik hills are seasonal in which the flow diminishes significantly during the dry season. The country is also endowed with 660 lakes and ponds of different sizes. The annual average precipitation of the country is 1,530 mm however there is large spatial and temporal variation in the rainfall distribution across the country. The eastern part of the country receives on an average of 2,500 mm of rainfall; Kathmandu valley about 1,420 mm and the western part about 1,000 millimeters (WECS, 2010). About 80 percent of the annual precipitation falls in monsoon from June to September and the remaining 20 percent of the precipitation distributes over remaining eight months, from October through May. The aridity increases with altitude and latitude, especially on the northern slopes, and reaches its peak in the inner and Trans Himalayan region and in the Tibetan Plateau. About 10% of the total rainfall in the country occurs in the form of snow fall (UNEP, 2001).

The hydrological responses of the snow-covered and glaciated areas are important in Nepal from the perspective of contribution to the country's water resources endowment. About 23% of Nepal's total area lies above the permanent snowline of 5000 m (MoPE, 2004). About 3.6% of Nepal's total area is covered by glaciers (Mool et al., 2001). About 10% of the total precipitation in the country falls as snow (UNEP, 2001). There are estimated 3,252 glaciers with covered area of 5,323 km^2 and an estimated ice reserve of 481 km^3 (Mool et al., 2001). All the lakes at elevation above 3,500 m are considered the glacial lakes. An inventory of the glacial lakes in the country has revealed existence of 2,323 lakes of different sizes in the upper mountainous areas of with the area coverage of 75 km^2. The contribution of the glaciers in the upper Himalayan region of the country are very important to sustain the river flow in the lean season and for downstream water uses.

An assessment of water resources availability and use in Nepal over the period 1991-2011 is presented in Table- 1. The annual renewable surface water available in the country is estimated to be 225 billion m^3 which is equivalent to an average flow of 7,125 m^3/s (WECS, 2003). In additional the renewable groundwater potential of the country is estimated to be 12 billion m^3 and much of the groundwater reserve is limited to the flat plains of Terai, Kathmandu valley and other hill river valleys. In comparison to this endowment of surface and groundwater in the country, only about 23.70 billion m^3 of water is estimated to be in use at present and much of this use is limited in agriculture, drinking water and sanitary uses. Other economic uses of water, such as those in hydropower generation, navigation, recreation and fishery are much limited.

The demand of water in the social and economic sectors, however, has increased significantly due to increase in the population and expansion in the economic and commercial activities especially in the urban areas. The per capita availability of water resources in the country, which is estimated to be 8,900 m3/capital/per annum, is at least 5 times higher than the threshold of 1,700 m3/capital per annum to meet all water needs in agriculture, water supply and sanitation, energy and environment (UNDP, 2006).

Table 1: Assessment of Water Resources Availability and Use in Nepal (1991-2011)

Particulars	**1991**	**2001**	**2011**	**Remarks**
Annual Renewable Surface Water (billion m^3)	225	225	225	Including the catchments outside Nepal
Annual Renewable Groundwater (billion m^3)	12	12	12	
Total Population	18,491,097	23,151,423	26,620,809	CBS (2011)
Per Capita Renewable Surface and Groundwater (‘000 m3/year)	12.81	10.23	8.90	
Total Annul Withdrawal (billion m^3/year)	12.95	16.70	23.70*	
Per Capita Annual Withdrawal (‘000 m^3/year)	0.69	0.72	0.89	
Sectoral Withdrawal as % of Total Withdrawal*:				
Domestic	3.97	3.68	3..43	
Industrial	0.34	0.41	0.41	
Agricultural	95.69	95.91	96.16	

Source: UNEP, 2001
FAO Aquastat (www.fao.org/nr/water/aquastat/data/query/results.html)
****Estimated value based on % annual increment 1991-2001***

3. Wastewater Production and Treatment

3.1 State and Sources of Wastewater Production

The production and management of wastewater in Nepal and problems associate thereto are probably as old as the investment in the development of modern piped water supply schemes. Piped water supply system in the country was stated as early as in 1895 in Kathmandu, essentially to serve the ruling elites that time. The system was later expanded to serve common people. Prior to this time the water needs of the people were met from traditional water systems which continue to meet significant part of the water needs of the people even to this date. The development of sewer system in the country was started only towards 1920s that include 55 km long brick channel to collect and dispose combined sewer and rainwater runoff in Kathmandu and Patan (Nyachhyon, 2006). In 1929, a government office with independent responsibility of operation and management of water supply infrastructure and services, named *Pani Goshwara*, was created which was the beginning of organized efforts in the development and management of water supply and wastewater system in the country. The modernization of water supply and sanitation infrastructure in the country began only after 1972 under the support of the World Bank, focused essentially to improvement in the urban water supply and wastewater services in Kathmandu Valley. This effort led to the formation of Water Supply and Sanitation Board in 1974 which was reorganized in 1989 and named Nepal Water Supply Corporation (NWSC) and entrusted with the responsibility of organizing, maintaining and managing water supply and wastewater services in the country. In 2008, the responsibility of operation and management of water supply and wastewater services in Kathmandu valley was transferred to Kathmandu Upatyaka Khanepani Limited (KUKL) under public private partnership. At present, the water utility under KUKL is estimated to serving 78% of the population in Kathmandu valley (ADB & GON, 2010).

The problems emerging from wastewater, especially the degradation of the water quality of the rivers and other water bodies due to haphazard disposal of wastewater and the associated health and livelihood consequence, started drawing attention of the government and the people after 1970s. Also, the problem was more pressing in urban areas of Kathmandu valley due to increasing concentration of population. Prior to this time efforts in wastewater management were limited to collection of wastewater originating from different sources through open and underground sewer lines and disposal of untreated wastewater in the rivers and other surface water bodies. Rivers in Kathmandu valley and in other parts of the country have been the main repository of untreated sewage, solid wastes and industrial effluents. Investment in the development of infrastructures and services for wastewater treatment in the country began only after 1970. During 1970s and 1980s centralized wastewater treatment plants were developed in many parts of Kathmandu valley though planned development of infrastructures and services for wastewater management in other urban areas of the country was started in much later in time.

The production of wastewater in Kathmandu and other urban areas in the country are through domestic, commercial and industrial routes. The sewer systems in Kathmandu and in other parts of the country are essentially combined sewerage and storm water drains and also illegal connection of sewerage to storm water drains are common in many parts of the country. Direct disposal of solid and liquid wastes along the river course and rainwater runoff originating from the urban areas and agricultural lands have also been responsible for significant degradation in the water quality of the rivers and other surface water bodies. Wastewater produced from the domestic routes includes grey water and black water produced in washing, cleaning, bathing and sanitary uses. Only small numbers of houses are connected to sanitary wastewater system and therefore most houses end up disposing the wastewater directly into the rivers and other water bodies. With 232 km long sewer system developed in Kathmandu Valley, only 40% of the population has access to sewer facility (ICIMOD, MOEST/GON, UNEP, 2007). Wastewater generated from the industries has been another source of wastewater. The industries producing significant amount of wastewater in the country include brewery and distillery, cement, cigarette and tobacco, animal feed, iron and steel, rosin and turpentine, soap and chemical solvent, oil and vegetable ghee, jute, paper and pulp, sugar and leather tanning. Total of 4,500 industrial units of different sizes are estimatied to be operating in different parts of the country. The concentration of industries are large in Kathmandu Valley and some urban centers (Birgung, Biratnagar, Bharatpur, Butwal and Bhairahawa) in Terai, adjoining Indian borders. Nearly 40% of the industries in the country are estimated to be producing significant amount of wastewater and nearly 50.9% of the total industries in the country are located within Kathmanedu Valley (UNEP, 2001). The combined wastewater production in three industrial estates in Kathmandu Valley- Balaju, Patan and Bhaktapur which house nearly 200 industrial units in the valley is estimated to be 800 m^3/day. Beside the industries located in the industrial estates where more organized facilities are developed for the management of solid and liquid wastes, there is are large numbers of small and medium scale industries scattered throughout the valley. The wastewater generated in most industries is mixed with the municipal sewerage system while the solid industrial waste is collected and dumped into pits or in open spaces. Since the waste water generated in the industries contain high loads of oxygen demanding wastes, synthetic organic compounds, inorganic chemicals and minerals, these lead to significant degradation in the water quality at the local level.

In addition to wastewater and sewage from domestic and industrial sources, the rivers also receive inputs of storm water directly from the roads and streets in the urban areas and the runoff originating from the agricultural lands. The streets in the urban areas contain different kinds of solid wastes in different volumes which get emptied directly into the river after every rain storm and become important part of wastewater and contributor of river pollution. Though the present level of use of inorganic fertilizers and other agricultural chemicals in Nepal is much lower than other countries in the region, the use of agricultural chemicals and fertilizers has increased in some areas, especially in Kathmandu valley and agriculturally prosperous districts in central and eastern Terai (Basnyat, 1999). Altogether 250 different types of pesticides are known to be in use in Nepal with the average use of pesticides to be 0.142 in the country (Palikhe, 1999). All the pesticides in use are organochlorides and organophosphates which are persistent in the environment and pass through the food chain through the processes of bioaccumulation and biomagnification, and thus are hazardous to human health. Organochlorides in the range of 34–100 ppb have been detected in samples of fish and plankton in three lakes, Begnas, Phewa, and Rupa, in the Pokhara Valley in the western mid hills of the country (Palikhe 1999).

No reliable data is available on the total volume of wastewater production from different sources and in the urban and rural areas of the country. In the absence of needed information, the daily volume of wastewater production is estimated based on average daily consumption of water per capita, which is taken 75 liters per capita per day in the urban areas and 40 liters per capita per day in the rural areas and 85% of this ending up as domestic wastewater (UNEP, 2001). Based on this consideration the total wastewater production in the country is estimated to be 296 MLD (Nyachhyon, 2006). The trend of urban growth and wastewater production in 10 major cities in the country over the period 1981-2011 is provided in Table 2, which is estimated to be 147.37 MLD. The volume of wastewater production in the urban areas has increased significantly which can be attributed to increase in the population, unplanned growth in the urban areas and rapidly changing consumption behavior. The volume of wastewater generated and collected in the wastewater management system in the five municipalities of Kathmandu valley, which are the most urbanized areas in the country is provided in Table- 3.

3.2 State of Treatment and Management Services of Wastewater

As stated earlier in this section there were limited efforts during 1970s and early 1980s to introduce sanitary sewerage systems for wastewater management in the country however much of these efforts were confined to the three urban areas of Kathmandu valley- Kathmandu, Patan and Bhaktapur. These included sewage treatment plants developed at Hanumanghat, Dhobigat, Kodku and Sallaghari to treat the sewerage prior to disposal into Bagmati River and its tributaries. These treatment plants comprise primarily of oxidation ponds and activated sludge ditch.

Table 2: Trend of Wastewater Production in the Principal Urban Areas in Nepal

Urban Center	Total Population 1981	Total Population 1991	Total population 2001	Total* Population 2011	Growth Rate 1981-2011 (%)	Wastewater Production (MLD)**
Kathmandu	235,160	421,258	671,846	1,081,179	11.99	68.92
Patan	79,875	115,865	162,991	225,237	6.06	14.36
Bhaktapur	48,472	61,405	72,543	97,500	3.37	6.21
Pokhara	46,642	95,286	156,312	210,457	11.06	13.42
Biratnagar	93,544	129,388	166,674	190,688	3.46	12.15
Birgunj	43,642	69,005	112,484	136,121	7.06	8.68
Bharatpur	27,602	54,670	89,323	107,226	9.61	6.84
Janakpur	34,840	54,710	74,192	84,916	4.79	5.41
Dhangadhi	27,274	44,753	67,447	84,244	6.96	5.37
Butwal	22,583	44,272	75,384	94,356	10.59	6.01
Total						**147.37**

Estimated based on total district population of 2011 (CBS, 2011)
*****Estimate based on total population of 2011***

Table 3: Wastewater Production the Municipal Areas of Kathmandu Valley

Description	**Municipalities**				
	Kathmandu	Patan	Bhaktapur	Kirtipur	Madhyapur-Thimi
Volume of Domestic Wastewater Generated (MLD)	64,497	15,647	5,971	3,920	3,069
Volume of Industrial Wastewater Generated)MLD)	4,515	1,095	418	274	215
Total Wastewater Generated (MLD)	69,012	16.742	6,389	4,195	3,284
Total Wastewater Collected (MLD)	34,506	8,371	3,195	2,097	1,642

Source: ICIMOD, MOEST/GON and UNEP, 2007

The existing state of some the wastewater treatment plants in operation in Kathmandu valley and in other urban areas of the country is provided in Table- 4. In 1999 Bagmati Civilization Integrated Development Committee (BCIDC), previously known as High Power Committee for Implementation and Monitoring of Bagmati Area Sewerage Construction/Rehabilitation Project, constituted with the aim of restoring environmental condition of Bagmati River, constructed Guheshwori Wastewater Treatment plant with the design capacity of 17.3 MLD of wastewater . The plant constructed with the aim of improving Bagmati River Environment at Pashupatinath Temple, has not been functioning only intermittently due to high operating cost and problem of foaming in the aeration tank.

Table 4 clearly shows that almost all of the large scale and centralized wastewater treatment plants developed in Kathmandu are either non-functional or they are operating much below their design capacity. The reasons, among others, have been higher cost of operation and maintenance and upkeep of the system. As an alternative to centralized wastewater treatment, options of decentralize management of wastewater are being promoted by the development organizations involved in the public health and environmental issues, such as UN-Habitat, Environment and Public Heatlh Organization (ENPHO), Municipalities and Community Groups.

Despite efforts over past three decades, the agencies involved in public health and environmental management, including municipal bodies, including those in Kathmandu valley, have failed to manage the growing volume of wastewater. The problems are aggravating every year in the urban areas due to increasing volume of wastewater generation as a result of accelerated growth in urban population, shortage of drinking water supply, and inability of the government and the municipalities to improve urban infrastructure and services, especially expansion of the sanitary sewerage system and roadside and storm water drainage in the urban areas. Ultimately, the sewage is dumped in the rivers without any kind of treatment.

4. Wastewater Disposal and Use

In Nepal, the practice of wastewater use in agriculture and in other uses and the emerging environmental and health consequences are not well documented despite the fact that the practice of wastewater irrigation has been age old tradition and intricately linked to culture and livelihood system of the people in Kathmandu valley. In Kathmandu valley, in the agricultural land located within the city centers and in the urban fringes, the farmers are known to practicing wastewater irrigation in significantly larger areas (Rutkowski, 2004). The practice of wastewater use in Kathmandu valley is largely informal and there is no institutional regulation for wastewater use, at least for now. The farmers practicing wastewater irrigation use wastewater from different sources which include municipal sewage, rivers carrying wastewater and water stored in the ponds and pools developed in the urban, peri-urban and rural areas. Almost no documented information is available on the practice of wastewater use outside Kathmandu valley though farmers in other parts of the country are also known to using wastewater in crop production.

Table 4: Existing Wastewater Treatment Plants in Kathmandu Valley and Other Urban Areas of Nepal

Location	**Type/Stage**	**Capacity MLD**	**Present State**	**Service Details**
Dhobighat, Patan (Kathmandu Valley)	1st Pond – Aerobic 2nd Pond – Anaerobic 3rd Pond – Facultative 4th Pond- Aerobic	15.4	Not working	HH Connections-53,900 Sewerage Lines-61,650 Combine channel- 44Km
Kodku, (Kathmandu Valley)	1st Pond – Aerobic 2nd Pond – Anaerobic 3rd Pond – Facultative 4th Pond- Aerobic	1.1	Partially working	HH Connections- 15,500 Sewerage Lines- 20,443 Combine channel- 11Km
Sallaghari, Bhaktapur (Kathmandu Valley)	Aerated lagoon	2.4	Not working	Details not available
Hanumanghat, Bhaktapur, (Kathmandu Valley)	Oxidation Ditch	0.4	Not working	
Guheswori, Kathmandu (Kathmandu Valley)	Oxidation Ditch	16.4	Partially Working	Sewers- 6 Km Population Served- 53,000 Urban area- 21 Ha
Hetauda Industrial Estate, Hetauda	Oxidation Pond	1.1	Working	Industrial Wastewater Treatment Plant
Dhulikhel Hospital	Reed Bed (Constructed Wetland)	< 0.10	Working	Without Primary Treatment Bed Size- 261 m^2 Population served- 330
Kathmandu Municipality	Reed Bed (Constructed Wetland)	< 0.40	Working	No Primary Treatment Bed Size- 362 m2 Population served- 330
Mulpi International School	Reed Bed (Constructed Wetland)	<0.25	Working	No Primary Treatment Bed Size- 376 m^2 Population Served- 850
SKM Hospital	Reed Bed (Constructed Wetland)	0.15	Working	Bed Size- 141 m^2 Population Served- 500

Kathmandu University	Reed Bed (Constructed Wetland)	< 0.035	Working	No Primary Treatment Bed Size- 587 m^2 Population Served- 1300
Middle Marshyangdi Hydropower Project	Reed Bed (Constructed Wetland)	< 0.026	Working	No Primary Treatment Bed Size- 298 m^2 Population Served- 870
Pokhara Municipality	Reed Bed (Constructed Wetland)	< 0.115	Working	No Primary Treatment Bed Size- 3,308 m^2 Population Served- 3830
Kapan Monastry (Kathmandu Valley)	Reed Bed (Constructed Wetland)	< 0.015	Working	No Primary Treatment Bed Size- 150 m^2 Population Served- 300
Tansen Municipality	Reed Bed (Constructed Wetland)	< 0.030	Working	No Primary Treatment Bed Size- 583 m^2 Population Served- 1000
Sunga Community Wastewater Treatment Plant (Kathmandu Valley)	Reed Bed (Constructed Wetland)	50 m^3/day	Working	Community Wastewater Treatment Plant Bed Size- 150 m^2 Population Served- 1200

Source: Nyachhyon (2006)

Shrestha (2011) carried out a systematic study on wastewater use and management practices in a traditional Newar settlement of Khokana in Kathmandu valley. He noted that Newars in Kathmandu valley have age old tradition of sustainable management of wastewater at the household and community level which involves elaborated system of collection, conveyance, storage and utilization of wastewater in agriculture and non-agricultural uses. The practice of wastewater management is also strongly linked to tradition of recovery of nutrients in wastewater for agricultural application. The practice of collection of wastewater in traditional Newar households in Kathmandu Valley is provided in Box-1.

Box-1
Traditional Wastewater Collection and Management in Traditional Newar Settlements in Kathmandu Valley

In traditional Newar houses, a traditional sink, locally called *Dhow Pwo* is generally made in the kitchen for the disposal of wastewater produced in cooking and hand washing and mouth rinsing. This traditional sink consist of bowl shaped burnt clay with narrow open burnt clay pipe called *Chee Dha,* conveying wastewater to a multipurpose wastewater collection pit, known as *Saagah* (*Saa* in Newari means manure and *ga* means pit, thus *Saagah* stands for pit excavated for the collection of wastewater preparation of compost manure). The wastewater collection pit or *Saagah* is generally found developed on an open space at the backyard of the house where solid and liquid wastes generated in the house are dumped for composting.

There is also practice of making a common *Saagah* in the courtyard. Traditional Newar settlements generally involve clustered housing stem with a court yard at the middle which is a common open space shared by the inhabitants. Wastewater from kitchen, biodegradable wastes and excreta from livestock are all collected and dumped in *Saagah* for composting. A small outlet made in the *Saagah*, called *'Byeku Pwo'* is connected to an earthen conduit, called *'Nali'* which drains the wastewater to the collector drains, collecting wastewater from all the households in neighborhood. The level of outlet in Saagah is set at a level that as soon as the pit is filled with wastewater to the level of the outlet it starts draining into the channel. Once the wastewater comes out of the individual houses through the earthen duct, its subsequent management becomes the community responsibility. The wastewater thus collected is either conveyed directly to the crop lands for irrigation uses or stored in the system of ponds where from the wastewater is recycled for subsequent irrigation uses. The ponds serve the purpose of oxidation tanks and hence they are part of traditional wastewater treatment system.

The traditional Newar households also practice their own sustainable system of solid waste management within the homestead. In traditional houses, an ash collection pit known as '*Naugah*' is made on the ground floor inside the house, usually located underneath wooden staircase, where the family members urinate which forms a mixture of urine and ash. This mixture gets matured in about three months time and then removed and transferred for use in the farm lands. In the early days an open space was kept close to the settlements for open defecation, called *'Mhola'* or *'Gaa'* for use by the female and male members in the community. This practice of open defecation is almost vanished in most settlements although this was widely in practice prior to 1960s.
(Source: Shrestha, 2011)

Shrestha (2011) also documented three models of wastewater management and use in the traditional Newar settlements in Khokana: i) stand alone system with individual households responsible for conveyance and disposal of wastewater from each house, ii) community system with wastewater irrigation integral to management of wastewater, and iii) community system with a community pond integral to management of wastewater. The standalone system of wastewater collection and management was noted to be in use in the households located at the edges of the main settlement. These households are generally involved in farming and livestock rising as the main occupation and major part of their farm lands located close to the homestead. The wastewater collected from individual houses is either conveyed and used for irrigation in the farm lands or in the kitchen garden within the homestead or allowed to get soaked in *Saagah*. Community system with wastewater irrigation integral to wastewater management was noted in the settlements with clustered housing surrounding a central court yard. Strom runoff from the court yard and the wastewater from individual and community *Saagah* are drained through a collector drain. Inter connected collector drains from neighboring courtyards aligned towards lower slope are meant for conveying storm runoff and wastewater to a main drain to convey the wastewater to the farm lands located along the lower slope. The size of the area brought to irrigation with such community system would depend on the number of houses draining effluents into the system, accordingly the system could be small, medium or large depending upon the number of houses and the courtyards connected to the system. Community system with community pond integral to the wastewater management system was noted to involve elaborated system of collection, conveyance and storage of wastewater and storm water in community ponds which are typical of traditional Newar settlements in Kathmandu Valley. Development of tanks and ponds as means of securing water for domestic uses has a long history in the Newar settlements in the valley which are also intricately linked to culture and religious value system of the people. The ponds, in addition to getting fed from storm water earthen ducts originating from the houses are also developed to discharge domestic wastewater into the ponds.

Shrestha (2011) observed that among the three models of traditional wastewater management practices in Newar settlements, agricultural use of wastewater is generally large in the second and the third model involving collection of wastewater from network of drainage channels and use of system of ponds for the collection of wastewater. He noted existence of seven community wastewater irrigation systems in one small area of Khokana with the size of the irrigated area under each system as small as 0.26 to 7.76 ha (Table 5). The most noticeable observation is that almost total dependence on wastewater for irrigation during dry season when other sources of water were not available for irrigation. The use of wastewater in the dry season in the study area was found being used for the production of vegetables which is important source of cash income for the people in the area.

Shrestha (2011) also observed that one of the very important aspects of traditional wastewater management system has been recovery of nutrients from wastewater and recycling the nutrients in the farm lands. He noted the practice of removing organic manures at different stages in the traditional wastewater management system. The wastewater collected in *Saagah* is known to promote accelerated decomposition of the organic wastes. The quantity of compost produced in *Saagah* was found to be

Table 5: Irrigation Coverage from Wastewater in Selected Community Wastewater Management System in Khokana

S. N.	Name of System	Location			Irrigation Coverage			Supplementary irrigation source
		Ward No.	**Name of the System**	**No. of Hhs**	**Total Area (ropani)**	**Coverage in the Wet Season**	**Coverage in the Dry Season**	
1.	Nhaya Bhu Tacha Dha	1	Nhaya Bhu	30	25	All	60%	None
2.	Duney Chey Chuke Dha	1	Dhuney Chey, Nhaya Bhu	40	50	All	75%	None
3	Lee Dha	2	Taa Jhaya	60	80	All	80%	Gaa Phuku
		3	Kalnani, Gaa Bhu	35				
4	Ghashi Dha	4	Thala Chey	55	150	All	75%	Kutu Phuku
		5	Kway Lacchi, Kutu Phuku	50				
5	Gha Dha	6	Nyah La, Nanicha	65	70	All	75%	None
6	Nani Chukye Dha	6	Nanicha	6	5	All	75%	None
7	Dhokashi Dha	7 8	Kway lachhi Dhokashi	40 20	20	All	50%	Fanga Phuku
	Total			**401**	**445**			

1 ha= 19.46 ropani
Source: Shrestha (2011)

determined by the size of the pit which was noted to be 3x3x2 feet in the household size *Saagah* and 6x5x3 feet in the community size *Saagah*. The composted manure from S*aagah* was found to be removed on an average of three times in a year with the average 300 kg of compost on each removal from household size *Saagah* and 750 kg compost on each removal from community size *Saagah*. Annually, this estimated to produce 900 kg of manure from the household size *Saagah* and 2,250 kg of manure from community size *Saagah*. The sediment deposited in the beds of the ponds and the drainage channels is considered another useful resource by the people, removed annually for application in the farm lands as soil conditioner. Application of organic manures in the agricultural land was considered by the farmers to improve the soil fertility and therefore contribute to increase in the coop productivity.

High nutrient content in wastewater was also considered by the farmers to contribute positively in crop production. In attempt to analyzing the nutrient content of wastewater, Shrestha (2011) noted average nitrate content in wastewater 6.95 mg/l, 4.9 mg/l, and 3.5 mg/l, respectively in Saagah, in the conveyance channel and in the wastewater storage ponds. Similarly, the concentrations of phosphorus and potash at the three stages were 3 mg/l, 10.7 mg/l and 4.35 mg/l and 42.9 mg/l, 149 mg/l and 27.7 mg/l, respectively. These nutrients present in wastewater are needed by the crops in large quantities for their growth and development and production.

Sada (2010) studied the practice of wastewater use in Hanumante River in Bhaktapur which is a tributary of Bagmati River. His study involved documentation of wastewater use practice in 55 farming households from the area who were essentially small farmers with the average landholding size of 0.23 ha. Hanumante River is the major stream in the areas passing through the urban core of the city of Bhaqktapur. The river carries domestic and industrial wastewater generate in the urban areas of Bhaktaur and Madhyapur-Thimi and also the river reach is used for solid waste dumping. The water quality analysis of the river from seven locations from upstream to downstream is provided in Table 6 which clearly shows that organic wastes in the river are major contributor of water quality degradation. Also, large concentration of fecal coliform in the river water is indicative that any direct use of river water, including irrigation, would be hazardous to human health.

Sada (2010) noted that as many as 64% of the farming households were using wastewater from Hanumante River for irrigation throughout the year while 34% of the them were using water for irrigation only during monsoon. As many as 62% of the farmers owned pump to lift water from the river for irrigation. The wastewater in the area was noted to be used in irrigating vegetables which is important means of cash income for the farmers in the area. The farmers were found selling their produces in the adjoining markets of Thimi, Bhaktapur and in Kathmandu. The farmers indicated increasing problems in selling their vegetables produced using wastewater. As many as 67% of the farmers indicated that the buyers restrain from buying vegetables produced in the area around Hanumante River because of the prevailing practice of wastewater use in vegetable production. Contrarily, 33 % of the farmers indicated that they did not face any difficulty in selling the produce to the consumers even though the consumers knew that the vegetables were produced using wastewater.

Table 6: Variation in the Water Quality of Hanumante River Used for Irrigation by the Farmers

S. N	Parameters	Unit	Sample ID							NWQS for Irrigation
			1	**2**	**3**	**4**	**5**	**6**	**7**	
1	pH	-	7.68	7.36	6.97	6.99	7.03	7.06	7.19	6.5-8.5
2	E.C	uS/cm	126	148	423	454	434	423	392	<40ms/m
3	DO	mg/L	7	5.3	0	0	0.8	1.5	0.7	
4	Calcium	mg/L	9.6	15.2	39.2	44.8	46.4	40	42.4	
5	Magnesium	mg/L	2.91	4.86	13.1	0.97	7.29	2.43	5.34	
6	Chloride	mg/L	7	7	29	29	28	26	23	<100
7	TSS	mg/L	5	75	65	56	98	31	36	
8	VSS	mg/L	11	18	50	47	33	27	20	
9	Total Solids	mg/L	169	206	234	318	318	270	254	
10	BOD	mg/L	3.5	4.7	79.9	67.4	28.9	25.9	18.9	
11	COD	mg/L	18.9	17.9	128	123	73.7	61.4	41.5	
12	Ammonia	mg/L	0.4	2.6	21.6	25.1	17.8	15	11.5	
13	Nitrate	mg/L	3.39	2.02	0.81	0.81	0.91	0.41	<0.2	
14	Total Phosphorus	mg/L	0.09	0.17	1.3	1.58	1.71	1.16	0.82	
15	Sodium	mg/L	8.07	9.23	22.9	26.5	23.8	22.0	19.1	<70 mg/l
16	Potassium	mg/L	3.52	4.11	15.6	16.9	14.9	14.1	9.49	
17	Chromium	mg/L	<0.02	<0.02	0.02	<0.02	<0.02	<0.02	<0.02	<0.1 mg/l
18	Lead	mg/L	<0.01	<0.01	<0.01	<0.02	<0.02	<0.02	<0.02	<0.2 mg/l
19	Zinc	mg/L	0.05	0.09	0.21	0.1	0.05	0.13	0.07	<1.0 mg/l
20	Faecal Coliform	CFU/100 ml	TNTC	TNTC	TNTC	TNTC	TNTC	TNTC	TNTC	<1 count/100ml

Note: 1-7 locations of water sampling upstream to downstream of the river course
NWQS- Nepal Water Quality Standard
Source: Sada (2010)

Sada (2010) also studied perception of the famers practicing wastewater irrigation on the effects of wastewater use in crop production. While only 20% of the farmers reported increase in the productivity of the crops with the use of wastewater, as many as 80% of the farmers opined reduction in the crop productivity with the wastewater application. Those farmers who opined decrease in crop productivity due to wastewater use, they attributed the reduction in the crop productivity to high nutrient content in wastewater. Farmers in the area have noticed drying and wilting of crops with the repeated application of wastewater.

The traditional wastewater management practice in Kathmandu Valley and also in other parts of the country has been declining rapidly due to changing socio-economic condition of the people and increasing awareness and consciousness of the people to health and hygiene. The practice of developing *Saagah* at the backyard of the house in the Newar settlement has almost totally been vanished except in some traditional Newar households in the rural areas. People have increasing preferences of connecting their toilets and wastewater system to sewer lines. This change in the practice has led to direct disposal of grey and black water in the rivers and open water bodies which has been responsible for increasing pollution loads in the river and other water bodies. Sada (2011) observed that practice of using wastewater in agriculture at present is limited to older generation while young boys and girls restrain from handling wastewater. Contrarily, the farmers practicing wastewater irrigation feel that with the change in the practice of wastewater for irrigation uses, they have been losing valuable nutrients that was being recovered and used in the crop lands (Shrestha, 2011).

5. Policies and Institutional Set-up for Wastewater Management

5.1 Policies and Legislations

Government of Nepal is currently drafting a policy on Wastewater Management (Draft Wastewater Management Policy 2006) to develop policy guidelines for planning, development, operation and management, financing and delineation of role and responsibilities of different stakeholders in wastewater management. The proposed primary objectives of the policy are: a) improving sanitary condition by ensuring compliance to the wastewater standards, b) reducing morbidity and mortality rates with appropriate wastewater management, c) facilitating construction and management of storm and sanitary sewerage systems, d) improving sanitary condition of local streams, rivers, lakes and ponds and other water bodies, e) establishing coordination and integrated approach among the stakeholders for planning, construction, operation, maintenance and management of sewerage system, f) establishing partnership between the government and private sector for promotion of appropriate technologies for wastewater disposal and management and financing, and g) developing mechanism for knowledge dissemination and awareness building among the stakeholders and beneficiaries. The Policy restricts disposal of wastewater into nature or open space without treatment to a safer level.

In the absence of separate policy for wastewater management, the related issues of wastewater management are dealt under the purview of sectoral policies and strategies relating to water supply and sanitation. Two documents that reflect upon the national commitment to the improvement of water supply and sanitation in the country are Rural Water Supply and Sanitation Sector Strategy (2004) and Urban Water Supply and Sanitation Policy (2009). Rural Water Supply and Sanitation Sector Strategy (2004) is based on national commitment of total water supply and sanitation coverage in the country as envisaged in the millennium development goal. Urban Water Supply and Sanitation Policy (2009) envisions improvement in the water service delivery in the urban areas, including improvement in the wastewater systems and services, promotion of public private partnership in the development of infrastructure and services and enforcement of national guidelines for safe disposal and use of wastewater. In attempt to improvement in the water supply and sanitation services National Guidelines for Hygiene and Sanitation Promotion (2005) has been endorsed which emphasizes:

i. increasing coordination among the agencies related to water supply and sanitation with the active role of National Drinking Water and Sanitation Committee at the central level.

ii. encouraging effective participation of non-governmental organizations and private sector in increasing the water supply and sanitation coverage,
iii. development of sewerage system with treatment plants with the active involvement of consumer groups
iv. prohibition of direct disposal of untreated sewage into water bodies

National Urban Policy (2007) highlights the historical imbalances and haphazard nature of urban development in the country. While the policy views the urban centers as the catalysts for economic development, continued environmental degradation and lack of services by the urban residents, especially the urban poor has been specifically emphasized. The policy emphasizes development of the capacity of Municipalities to plan and manage integrated local development activities, including the preparation of urban master plans in coordination with the central authorities. Private sector involvement and investment in infrastructure development has been specifically sought in the Urban Policy.

The legislations and regulatory provisions encompassing the issues relating to wastewater management and safeguarding of water bodies include: Environmental Protection Act (1996), Local Self-Governance Act (1999), Industrial Enterprises Act (1993), National Wetland Policy Act (2003), National Sanitation Act (1994), Pesticide Act (1992), Solid Waste Management and Resource Mobilization Act (1988) and Water Resources Act (1992). The key element of these legislations are as stated hereunder:

Environment Protection Act (1996): This Act focuses on the protection of environment with the proper use and management of natural resources, taking into consideration that sustainable development could be achieved from the inseparable interrelationship between the economic development and environment protection. The act also sets the legal provisions in order to maintain clean and healthy environment by minimizing, as far as possible, adverse impacts likely to be caused to human beings, wildlife, plants, nature and physical objects as a result of environmental degradation.

Local Self-Governance Act (1999): Local Self-Governance Act grants higher level of autonomy to the local bodies in development planning and mobilizing resources to undertake development works at the local level. The local bodies in the context of this act have been considered to mean Village Development Committees (VDCs), District Development Committee (DDCs) and the Municipalities. The act also empowers the local bodies to manage the natural resources within the areas of their administrative jurisdiction and generate revenues by contracting out extraction of the natural resources.

Industrial Enterprises Act (1993): This act was promulgated to give due consideration to the environmental and pollution problems emerging from the establishment of industries and industrial districts. This Act empowers the Ministry of Industry to withhold the permission for the establishment of those industries which are causing or likely to cause adverse impacts on the environment.

National Wetland Policy Act (2003): The National Wetland Policy Act sets legal provisions for the conservation and management of wetlands. The act also lays out provisions to formulate wetlands management plan and administrative arrangements for the representation of local people and organizations in the management committee relating to the conservation and management of wetlands and related resources.

National Sanitation Act (1994 A.D.): National Sanitation Act is focused to safeguarding water sources and ensuring environmental sanitation for the protection of environment. This also deals with creating awareness and knowledge and awareness building on sanitation and hygiene practices among all section of population, focusing specifically on women and children and bringing attitudinal and behavioral changes within the community.

Pesticide Act (1992): Pesticides act lays out legal provisions with regards to use of chemicals for the control of agricultural and domestic insects and pests. The act has also restricted use of certain types of chemicals considering their damaging effects to the environment. This act sets provisions with regards to import, export, production and consumption of pesticides for which clearance of the government has been made compulsory.

Solid Waste Management and Resources Mobilization Act (1988): This act focuses on solid waste management in Kathmandu, Bhaktapur and Lalitpur Municipalities. The act lays out regulatory provisions for the implementation of the activities and mobilization of resources for solid waste management in the stated areas. The act sets out provisions for the collection, handling and disposal of solid wastes in the manner that it does not cause environmental damage in the area designated for the disposal of the solid wastes. The roles and responsibilities of the citizen relating to collection and disposal of solid wastes have been identified and set by the act.

Water Resource Act (1992): This Act defines "water resources" as any form of water available in Nepal, in the forms of surface or groundwater. The act prohibits the activities that may cause pollution of the water bodies and maintains that the utilization of the water resources should be made without causing any damage to the environment in the forms of soil erosion, floods, landslide and mass wasting that may cause damage to the water bodies. The act sets the priority of water use based on the utilization that ranks drinking water and water for domestic uses in the highest priority followed by irrigation, agriculture use and animal husbandry, hydroelectricity, cottage industry and mining use, navigation and recreational uses. The act also sets standards for water quality for different uses and provision of license for any form of commercial use of water.

With regards to the prevention of pollution of the water bodies, section- 19 of the act lays the provision that reads as- *"No one shall pollute water resources by placing litter, industrial wastes, poisons, chemicals or other toxicants to the effect that it exceeds the pollution tolerance limit".* Similarly on imposing fines/sanction on the act of the causing pollution of water bodies, section 22 of the act lays down the provision that reads, as- *"Any person or corporation found liable to causing pollution of water bodies shall be fined up to NRs. 50,000 and must pay compensation to the individuals and communities sustaining the loss as a result of the pollution".*

5.2 Institutional Arrangements for Wastewater Management

Ministry of Physical Planning and Works (MPPW) has the overall responsibility of making policies and development plans and administering water supply, sanitation and transport sector and related physical infrastructure development in the country. The Ministry of Physical Planning and Works has established a Sanitation Division responsible to render technical assistance to bilateral and multilateral organizations in formulating, monitoring and evaluating sanitation programs, including urban and rural rainwater and domestic sewerage, except the road drainage system.

Department of Water Supply and Sewerage (DWSS) under MPPW is responsible for planning and development of water supply and sanitation systems and related infrastructure development in the country. The responsibilities of DWSS encompass the rural and small urban centers in the country. Nepal Water Supply Corporation (NWSC) has been created as a semi-autonomous corporation responsible for water supply and sewerage in major urban centers outside the Kathmandu Valley. In Kathmandu Valley the responsibility of development, operation and management of infrastructures and services for water supply and sewerage system lies with Kathmandu Upatyaka Khanepani Limited (KUKL), an institutions created under public private partnership. Local Self Governance Act (1999) sets out the duties of local government-municipalities and VDCs with regards to drinking water, irrigation, sanitation and water conservation. The main role played by local governments is expected to be development of water and sanitation facilities by developing local plans, programs and also providing the materials and financial support for the development of infrastructures and services by the local community.

5.3 Regulation of Wastewater Use in Agriculture and Other Uses

While the formulations of environmental policies, institutions and legal instruments to ensure environmental compliance have received increasing attention beginning 1990, the enforcement of the policies and regulatory provisions continue to be weak. Two reasons that are known for this state have been lack of inter-institutional coordination and commitment to the enforcement of legal instruments. This has been essentially due to inadequate foresight and understanding of the long-term benefits of environmental protection by the concerned institutions and their personnel. Continued political uncertainty in the country beginning 1990 has been another reason for the weak enforcement of the regulatory provisions.

The regulations relating to wastewater use in agriculture and other uses are weak in the absence of needed regulatory provisions and absence of institution with the autonomous responsibility of wastewater use and management. There is no effluent quality specified for the disposal of wastewater in the water bodies, however the quality criteria that is generally referred for most agencies for different uses of water is provided in Table- 7. In 2008 quality guidelines for safe use of wastewater in agriculture, aquaculture, animal watering, recreation and environment was formulated which was published in the Gazette of the Government of Nepal (Sada, 2011)

There is no institutional arrangement to regulate the wastewater use in agriculture and also there are no guidelines available to ensure safe handling of wastewater and the agricultural produces. Considering that wastewater use in agriculture would accelerate in the country in the days to come, at least in the urban areas like Kathmandu, developing wastewater irrigation guidelines would be the crucial first step to approach the wastewater use in agriculture.

Table 7: Water Quality Standards for Different Uses Referred by Water Agencies in Nepal

Parameter	Drinking	Aquatic life	Bathing	Agriculture
pH	6.5-9.2	6.5-8.5	6.5-9	6.5-9
TDS (mg/l)	1500	1000	1500	500-3000
SS (mg/l)	-	25	50	-
DO as O2 (mg/l)	-	6	3	3
Cl as Cl (mg/l)	600	500	1000	100-1000
SO4 as SO4	400	500	1000	1000
NO3-N as N (mg/l)	-	20	20	25
NO2-N as N (mg/l)	-	0.15	1.0	1.0
NH3-N as N (mg/l)	-	0.02	0.2	0.2
Total PO4 as PO4 (mg/l)	0.1	0.1	0.2	0.2
BOD as O2 (mg/l)	4	4	6	10
F as F (mg/l)	3	1	1.5	1.5
Total Hg	-	0.0001	0.001	0.001
Total Cd	-	0.005	0.005	0.01
Total Pb	0.05	0.05	0.05	0.1
Cr	-	0.05	0.05	0.1
Phenol	0.002	0.005	0.1	0.2
Total Cyanide	-	0.005	0.2	0.2
Total Colliform (MPN/100ml)	-	-	1000	1000

Source: Sharma et al. (2005)

6. Research on Wastewater Systems and Use

Research and knowledge development and dissemination of pertinent knowledge on wastewater management are highly scattered and non-systematic in Nepal. The research efforts are limited to small number of educational and research institutions and development organizations and the professionals engaged thereto whose areas of involvement have been as stated hereunder:

i. Analysis of state of water quality degradation in the surface water bodies (rivers, lakes and ponds) including limnological studies in the surface water bodies.
ii. Assessment of performance of technology and infrastructures relating to wastewater management.
iii. Health and livelihood consequences and disease dynamics emerging from water quality degradation.
iv. Interdisciplinary analysis of processes and outcome of degradation of surface and groundwater systems.

v. Technology options for decentralized wastewater treatment.
vi. Policy research on surface and groundwater use and management.

The organizations involved in research and knowledge development in wastewater system include Universities, Research Organizations and units in the government Ministries and Departments with the independent responsibility of research and development and small number of development organizations involved in development and policy research. These include:

i. Central Department of Geography under Tribhuvan University
ii. Institute of Engineering under Tribhuvan University
iii. Kathmandu University
iv. Nepal Engineering College under Pokhara University
v. International Center for Integrated Mountain Development (ICIMOD)
vi. Environment and Public Health Organization (ENPHO)
vii. Institute of Social and Environmental Transition-Nepal (ISET-Nepal)
viii. Nepal Agricultural Research Council
ix. System Management and Training Program (SMTP) under Department of Irrigation
x. Nepal Health Research Council under Ministry of Health

Some of the key achievements in research and knowledge development in wastewater system and management in Nepal, to this date, have been as stated hereunder:

i. Systematic analysis of water quality in the rivers of Kathmandu valley carried out by Department of Hydrology and Meteorology (DHM), Government of Nepal and ENPHO during 1992-1996
ii. Classification of River Systems in Hindu-Kush Himalayan Region carried out by ICIMOD during 2006-2007 based on water quality criteria which also included rivers in Kathmandu valley.
iii. Kathmandu Valley Environmental Outlook prepared by Ministry of Environment Science and Technology in support of ICIMOD and UNEP in 2007
iv. Design Optimization and Promotion of Decentralized Wastewater Management System in Nepal by ENPHO

The agencies with the responsibility of improvement in the practices of agricultural water use are Department of Irrigation (DOI), Department of Agriculture (DOA) and Department of Local Infrastructure Development and Agricultural Roads (DOLIDAR). DOI is entrusted with the responsibility of design, construction, operation and management of irrigation infrastructures and services in the counry. Irrigation schemes larger than 25 ha in size fall within the responsibility of DOI. DOLODAR started a program on community based irrigation development beginning 2011, focusing on small scale community based irrigation schemes smaller than 25 ha in size. DOA is entrusted with the responsibility of dissemination of appropriate agricultural technology and practices in the irrigated and rain fed areas with the aim of improving agricultural productivity. Nepal Agricultural Research Council (NARC) has the responsibility of research and technology development and promotion of appropriate agricultural technology in the irrigated and rain fed farming system. None of these agencies have specific program on research and development or promotion of technology and practices relating to wastewater use and management in agriculture.

No research project specifically focused to wastewater use and management, looking into social, economic, technological, environmental and health and livelihood concerns, are known to be underway in the country. A research on Peri-Urban Water Security is underway at Nepal Engineering College beginning July 2010 with support under IDR with the aim of developing understanding on processes of water uncertainty and emerging water security concerns. The research project undertaken over here years time involving four cities (Nepal- Kathmandu; Gurgaon and Hyderabad- India and Khulna-Bangladesh) in three counties in South Asia. Practices of wastewater use and management is important area of focus wherein the team of researchers have documented the practices of wastewater management and its use in agriculture at four study locations within Kathmandu Valley.

7. Knowledge Gaps and Needs for Safe Wastewater Use

No analysis is available to date on the state of knowledge and knowledge gap on safe wastewater use across different water sector agencies and their personnel in the country. This lack of emphasis on assessing the knowledge gap on safe use of wastewater is probably due to existing perception of considering wastewater as environmental ‘nuisance’ and not as a ‘resource’ by the water sector agencies and their personnel. Much of the emphasis to date has been on the development of physical infrastructure and services in the collection, conveyance, treatment and safe disposal of wastewater where as recycling and reuse of the wastewater has received little emphasis in the development and execution of the development programs. Part of the reason for not considering wastewater as potential resource for productive uses in agriculture and other sectors has been lack of institutional coordination across the water sector agencies. Water sector development in the country highly sectoral with sectoral policies dominating the development of water systems and services in each sector.

In the course of preparing this country report, relevant Government Ministries and Departments and their personnel working at policy and key decision making positions were contacted and their views on the relevance, state and need of knowledge on wastewater management and safe use of wastewater their day-to-day engagements in delivering the services were assessed. The information provided hereunder are based essentially on this survey which was undertaken in a very short period of time. The personnel in the Government agencies identified the gaps at two levels-i) gaps in internalizing and safe use of wastewater as institutional agenda of the agencies and ii) gaps in program planning and execution.

The gaps in internalizing the safe use of wastewater as regular program agenda stems essentially from lack initiative on part of the water sector agencies in considering possibility of wastewater use as a part of their water development programs. Water Resources Strategy endorsed by the Government of Nepal in 2002 envisions integrated approach to water resources development wherein exploring the possibility of wastewater recycling/use has been identified as one of the alternatives to approaching/enhancing water security, at least in the areas that are known to facing scarcity of water. There has also been, in general, adequate regulatory provisions and legislations to promote safe use of wastewater. The water quality standards for safe use of wastewater in agriculture, aquaculture, livestock watering, recreation and environmental uses, published in the Gazette of the Government of Nepal in 2008 enforces the national commitment to promote safe use of wastewater. Contrarily, the emphasis in translating the policy emphasis into actual plans and programs for safe wastewater use has been largely lacking in most water sector development agencies and also those concerned with the health and environmental issues.

The identified gaps in the program planning and execution by relevant water sector agencies, as revealed by their key personnel is presented in Table- 8. While the personnel in most water sector agencies and those relating to health and environment revealed high level of relevance and importance of knowledge on safe use of wastewater, they invariably also identified low level of current emphasis on developing programs and plans in promoting safe use of wastewater. All of the agencies also identified high level of needs in developing institutional capacity, in terms of development and addition of human, materials and technology resources for their enhanced roles in the promotion of knowledge and practices in safe use of wastewater.

Table 8: Gaps in Program Planning and Execution Relating to Safe Use of Wastewater across Selected Water Sector Agencies

Levels of Gaps	MOA&C	MOPPW	MOH	MOE	DOI	NARC
Relevance of Knowledge on Safe Use of Wastewater	High	High	High	High	High	High
Sectoral Policy Emphasizing/Encompassing Wastewater Issue	NE	Adequate	Adequate	Adequate	NE	NE
Resources (Material, Technology and Human Resources) to Address Safe Use of Wastewater	Low	Medium	Low	Low	Low	Low
Programs/Plans in Promoting Safe Use of Wastewater	Low	Low	Low	Low	Low	Low
Need of Institutional Capacity Building on Safe Use of Wastewater	High	High	High	High	High	High

NE- Non existent

8. Concluding Remarks

This paper attempted to present the state of water production and usage in context of Nepal and the existing policy guidelines and regulatory frameworks guiding safe use of wastewater in the country. The last section of the paper looked into the knowledge gap and the needs of capacity building of the water sector agencies and their personnel on safe use of wastewater in the country. While this paper presented broader picture of wastewater production, management and use in the country, this also attempted to draw upon the micro-level perspectives, especially the traditional practices of wastewater use in Kathmandu valley, in portraying the state and potential of wastewater use in the country and therefore need for promotion of knowledge and practices for safe use of wastewater management. Following conclusions emerge based on the contents and analysis of this paper:

i. Wastewater management and use in Nepal was noted to be age old practice, intricately linked to traditional knowledge and wisdom of the people. Traditionally wastewater is considered 'resource' by the people while the development efforts of water sector agencies relating to wastewater management has been essentially guided by the notion of considering wastewater as a 'nuisance' and key contributor of environmental pollution. This notion was found emerging from sectoral and disciplinary perspectives in water system development which is essentially guided by technology solution to all water problems.

ii. The wastewater production in the country was noted to have increased significantly since 1970, especially in the urban areas due to accelerated increase in population, unplanned and haphazard development of infrastructure and services for water supply, sanitation and wastewater management. The analysis also clearly revealed that the pace of development of infrastructure and services for wastewater management has been largely inadequate and incomplete to meet the needs. Also, centralized and technology based solution to wastewater management was noted to have failed in addressing the wastewater problem, especially in the urban areas like Kathmandu.

iii. The analysis noted commitment at the policy level in addressing the problem of wastewater management in the country. The existing legislations and regulatory provisions were also noted to be generally adequate to address the problems of wastewater management. Contrarily, the gaps were identified at the levels of execution of the policies, legislations and regulatory provisions relating to safe use of wastewater. Gaps were also noted at the level of institutional development and in internalizing the problem of wastewater management as important area of development intervention by the water sector agencies.

iv. The analysis noted lack of emphasis on research and development in the country in improving the state of knowledge, practices and solutions to wastewater management. There are only small number of agencies and their personnel who have limited level of engagements in research and development on wastewater use and management. This has been essentially due to lack of national emphases on promotion of wastewater use.

v. The key conclusion emerging from the analysis is the need of considering safe water use as important area of water sector development in the country. There are visible water stresses, especially in the urban areas, emerging from dry season water uncertainty groundwater depletion and climatic variability. There are established potential of promoting wastewater use as means to addressing water uncertainty and approaching water security at the local level. Considering emerging concerns on climate induced water uncertainty in the country, especially the concerns on likely depletion in the water resources due to climate change, definite potential lies in considering safe use of wastewater as important means to preparedness and adaptive strategies to possible future water security.

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