

Ecosystem Health and Environmental Education in South Asia

Mamta Singh^{1,*}, Sandra West²

¹Lamar University, TX

²Texas State University, TX

*Corresponding author: mamtasingh1328@gmail.com

Received March 31, 2014; Revised April 17, 2014; Accepted April 20, 2014

Abstract The principal recent change in rural land-use in the south east valley is that rural areas are being absorbed into growing towns and cities. This conversion of rural into urban land has several impacts on river water quality because of developments such as industrial installations, which are located along the banks of environmentally vulnerable rivers. The NakkhuKhola, which is one of tributaries of the River Bagmati flowing through the heart of Kathmandu valley was studied. It was found that the highest percentage of agricultural land was in the up-stream station, which was not yet influenced by industrial pollution. Less agricultural land existed in the mid-stream station, which was a newly formed urban area with domestic and industrial effluents as a major source of river pollution and the down-stream station experienced moderate load of pollutants from domestic and industrial effluents. The socio-economic condition of the local communities a social survey was conducted among the residents of the three sampling sites viz. up, mid and down-stream and respondents sex, age and education level were considered as their characteristics. The results suggested that none of the communities were dependent upon the river as a drinking water source, although the river was used for various other purposes such as irrigation, water and bathing of livestock, industrial use, waste disposal site, pebbles collection, fishing. The results further suggested that although people were aware of pollution, their awareness was not yet transferred into action, which was mainly because of lack of regulation, planning, monitoring, and implementation of environmental policy.

Keywords: *land-use, river pollution, socio-economic, Kathmandu, Nepal*

Cite This Article: Mamta Singh, and Sandra West, "Ecosystem Health and Environmental Education in South Asia." *Journal of Environment Pollution and Human Health*, vol. 2, no. 2 (2014): 34-43. doi: 10.12691/jephh-2-2-1.

1. Introduction

Recent changes in land-use in the Kathmandu valley reflect shifts in the relative importance to the resident population of agricultural and non-agricultural activities and the degree to which the population's activities have impact on the natural environment. Land-use activities form the cultural landscape including agriculture (whether irrigated lowland, rain fed lowland or upland); fallow or grass land; public or private plantations; household residences (including houses, farms, buildings, factories, kitchen gardens); road surfaces; canals, bridges and other waterways; and public buildings such as schools, temples and so forth (Turner & Meyer, 1993). Rivers are valuable yet finite natural resources affected by human activities. Streams and rivers are specialized habitats for plants and animals. These ecosystems are particularly sensitive to change induced by human activities to water balance, water chemistry and habitats Twesigye, *et al.* (2011). The quality of river water is an ever-increasingly important issue. With time, increasing water demands have emerged for drinking, personal hygiene, religious activities, fisheries, agriculture (irrigation and livestock), industrial

production, hydropower generation and recreation activities such as swimming and fishing. Simultaneously with these uses, in South Asia, since ancient times, water has been considered as the most suitable medium to clean and disperse. However, unfortunately these water bodies are used as dumpsites for domestic and industrial wastes. The extent to which human activities influence the environment has increased dramatically over the past few decades, affecting freshwater significantly. The scale of socio-economic activities, urbanization, and industrial operations has a widespread impact on water quality.

Freshwater water quality degradation is one of the major problems caused by disposal of untreated wastes often associated with rapid population growth, intensification of agriculture, inappropriate methods of fishing, urbanisation and industrialisation (Shakya, 2000). The natural environment possesses the capacity to assimilate pollutants to some extent, but beyond a certain limit pollutants accumulate and become toxic and thus lead to environmental degradation (Shakya, 2000). The pollution problem not only leads to inaccessible drinking water supply and endangers public health but also alters the ecosystem as a whole, affecting aquatic flora and fauna, which may cause serious damage to these species and will, may lead to the extinction of species, altering the

entire ecosystem (Shakya, 2000 & Shah, 2009). Untreated or inadequately treated effluents discharge from industries, construction of hydropower dams, use of toxic chemicals for fishing, seepage of pesticides (such as herbicides and insecticides) used in agriculture, untreated sewage discharge are among the important issues related to freshwater pollution. In recent years, due to the above-mentioned threats, freshwaters are facing a massive problem of pollution and if effective interventions are not made it will not only affect the aquatic biota but the entire ecosystem as a whole, thus affecting the livelihoods of communities dependent on these natural resources in addition to direct threats to human health. This is especially true for less developed countries (LDCs) where much of the waste is dumped in rivers and other water bodies without any or adequate prior-treatment. Change in land-use adjacent to water bodies may lead to changes in water quality. Furthermore, land-use changes are related to the development activities and to the socio-economic development of the country.

The socio-economic development of the country is usually measured in terms of per capita income of inhabitants. The per capita income can be geared up with the involvement of work force, often in industries. The changes of job opportunities from purely agriculture to the industrial sector provide a solution to some extent to upgrade the living standard of the people. Industrialization helps to solve the problem of employment and serves commodities required for the people and for national development. It is also called the 'engine of growth'. Hence, industrialization is accepted as the mark of civilization. However, industrialization is a unidirectional development with maximum utilization of existing natural resources but often lacks the concept of environmental management and protection. This is because development and conservation were regarded as the two polarised concept in the past (EISP/HMG, 1987). Problems of pollution emerge from various industries, depending on the use of raw materials and type of products. The urgent need for environmental management and protection has been realized recently in both developed and the LDCs. However, we still are facing a challenge of balancing both development and environment. These components cannot be treated as mutually exclusive components, however, needs to be kept in natural harmony.

The Bagmati River represents the symbol of Hinduism in Nepal and in the neighbouring country India. The river originates from Shivapuri hill at Baghdwar about 15 km north to Kathmandu city. The total length of the River Bagmati is about 30 km from Shivapuri to Chovar. Tragically, this holy river has degenerated into an open sewerage, for not only do all drainage pipes lead to the river, effluents from industries all over Kathmandu valley also discharge hazardous chemical wastes into it. Today, the Bagmati River stands as one of the biggest environmental problems in Kathmandu. Not only is the water of the Bagmati unfit for irrigation, studies reveal that its ecosystem has been destroyed (Shakya, 2000). Rapid increase in human population and unplanned change in land-use practises are some of the root causes of the degraded condition of river ecosystem. The water quality becomes poor when it enters urban areas. This degradation is largely due to industrial developments and their effluents, unplanned sewage disposal and dumping of

solid wastes. Most of the pollution originates from domestic sewage (NESS, 1998). The domestic sewage and industrial effluents draining into the valley are poorly organised. There are no separate drainage channels for sewage, urban-run off and industrial wastes. It is clearly visible that at many points untreated raw sewage containing human excrement is directly discharged into the rivers. The river water quality parameters such as BOD, COD, chloride and nitrogen contents and turbidity reach high levels when they enter urban or settlement areas (Shakya, 2000).

Today not only the river Bagmati but also its tributaries are facing the problem of pollution. The five main tributaries of the river Bagmati in the Kathmandu valley are Bishnumati, Dhobi Khola, Manohara, Balkhu and NakkhuKhola. The water in the tributaries of the Bagmati River (except Bishnumati river) is generally less polluted than the Bagmati River itself, and are partly suitable as a source for water supply, recreation and irrigation etc. Various studies have been carried out with regard to the water quality of Bagmati River (Pradhan, 1998, Dixit, 1998 and Shakya, 2000), but very few have been conducted on the tributaries of the Bagmati River although now they are of concern. This study focuses on an assessment of the water quality of one of the tributaries of Bagmati River, the NakkhuKhola River. This study examines land-use with respect to the population growth, urbanization and development activities. In addition a social survey was also conducted in relation to pollution and conservation awareness of the NakkhuKhola, to look at river uses by the villagers, to find out the perception of local people concerning the change in the river over past decades and their effect upon them. The present research will address the following research questions:

- What kind of different activities are conducted in and round the river?
- Assess people awareness and attitude of degrading river water quality
- What kind of conservation methods can be adopted to protect the degrading river water quality?

2. Literature Review

Since last three decades the country is facing water pollution as a major environmental problem. The problem is mainly concentrated in the Kathmandu valley compared to the other parts of the country. The Bagmati River, which drains the Kathmandu valley, is highly polluted in different stretches and its water is unfit for human consumption. Researchers have investigated the impact of pollutants upon aquatic life and human health for over 150 years (Davis & Simon, 1995). Canter (1985) and Bartram & Ballence (1996) studies suggested that water quality reflects the composition of water as affected by natural causes and human cultural activities, expressed in terms of measurable quantities and related to intended water uses. According to Devkota & Neupane (1994) localized industrial pollution is on the rise in Nepal. Pradhan (1998) in her study of water quality assessment of Bagmati River and its tributaries suggested that the physico-chemical parameters such as temperature, colour, odour, conductivity, pH, hardness, dissolved oxygen, ammonia, phosphorus, BOD and chlorides generally affect rivers which receives urban sewage and wastewater, urban

runoff, agricultural activities, wastes disposal etc. One-year water quality monitoring record of the river Bagmati indicates a high level of discharge and/or disposal of oxygen demanding wastes in river. The concentration of BOD and COD indicates an increase from October to March (MPE, 2000). An earlier monitoring study of river water in Nepal also revealed water quality to be generally good along the riversides, with the exception of areas close to the human settlements. Water quality to some extent is degraded due to lack of sewage treatment. According to a report published by Nepal Water Supply and Sewerage Co-operation NWSSC (1997), only 26,141 (17%) households in Kathmandu are connected to public sewerage system. The remaining houses discharge their sewage into septic tanks, latrines or directly into the river systems. The public sewerage pipes also directly drain into both Bagmati and Bishnumati rivers. Shakya (2000) investigated that the river water from the source to 5.2 km in the Bishnumati River and 8.4 km in Bagmati River and found that it is within the limit of aquatic habitat that is they contain aquatic life. From these points downstream pollution gradually increases until the water becomes almost like a sewer and river is biologically dead (GoN/NTNC, 2009).

Singh *et al.* (1998) observed physical and chemical characteristics of water in relation to pollution of river Ramganga, India fairly close to Nepalese boarder. On the basis of their studies, they concluded that the middle stretch of the River Ramganga is highly polluted due to different effluents released from various factory wastes containing high loads of organic matter. The river water is completely unfit for general use. The land-use in the present study refers to the change of agricultural land into residential areas associated with industrial and urban development. According to Ward (1989), anthropogenic impact is the most important factor to bring about change in the state of river ecosystems. Sharma (1998) and Chhetri (2006) stated that due to a tremendous increase in unplanned, unsustainable construction, and building activities (both in public and private sectors), the water quality of rivers flowing through the capital city of Nepal have undergone swift deterioration over the last decade. As the population of the valley increased so did the garbage and more wastes found their way into the main river of the Kathmandu. NESS (1998) reported that domestic effluents contribute more to the river pollution than industrial wastes. It was stated that domestic effluents accounted for about 85 percent of pollution in the Bagmati River. The study of population environment interactions in Nepal is important because population growth, migration, and other demographic changes have been closely linked to change in land use and environmental quality in many regions of the country, and because there is a call for case studies which document the natural and social drivers of land-use changes and loss of biodiversity (Turner *et al.*, 1993). Sewage waste is the result of urbanization and is mostly discharged into water bodies. With the increase in pollution, the quantity of sewage produced and discharged into water bodies has also been increasing. The sewage waste which includes human excreta, soaps, detergents and garbage containing waste papers, cloths, kitchen washing etc. is the main cause of pollution of water bodies (Bubb & Lester, 1995).

3. Methodology

3.1. Study Sites: Kathmandu Valley and Environmental Settings

The Bagmati River (of which NakkhuKhola is one of the tributaries) is considered as a holy river for the Hindu people of Nepal. This area is the confluence point of Bagmati and Nakkhu and is important from religious point of view, especially for those people residing near or close to that area. Several religious activities affect water quality such as washing down of ash after cremation, washing down of religious goods at the end of the ceremony, bathing for purification, and other religious activities. The sources of pollution in this area are solid waste disposal, agricultural run-off, washing of animals and, livestock faecal contamination. The Kingdom of Nepal lies in the central hill region of Nepal. The country is roughly rectangular in shape. The east-west axis is about 875 km and its north-south width varies from 130 to 240 km. The northern border lies with the Tibetan autonomous region of China whereas the eastern, southern and western borders with India. The country is landlocked. The total area of Nepal is 147,181 sq. km. The total population of the country is around 26.6 million (CBS, 2013) with an annual rate of increase of about 2.1%. About 76% of the people are engaged in agriculture and rest are in the service and industry sectors. Kathmandu is the capital and one of the fastest growing cities of Nepal. It is situated in the mid-hill region of the country. Within the city flows the non-snowfed river Bagmati, emerging from the Shivapuri range of the southern part of Mahabharat mountains. Kathmandu valley comprises an area of about 240 sq km. **Geology:** Kathmandu Valley is tectonic in origin. The valley floor is made up of fluvio-lacustrine deposits with vertebrate fossils of Quaternary age. There are dominantly clay and sands with minor gravel beds. This valley consists of sedimentary, schist, gneiss and granitic rock terrain. These sediments are formed between Precambrian and Tertiary age (HMG/ICIMOD/CDG/UNEP, 1994). The soils of the area range from loamy sand on the northern side to sandy loam to the valley floor. **Climate:** The climate in the Kathmandu valley ranges from subtropical to warm temperate. Kathmandu valley receives an average annual rainfall of 3,220 millimetres. The highest precipitation is on the southern slopes of Shivapuri i.e. 2,404 mm per year (Shakya *et al.*, 1997). The maximum rainfall occurs in summer, especially from June to August, but the winter does not remain completely dry. For this particular study, three research sites were selected based on land-use pattern, rural, sub-urban, and urban sites on one of the tributaries of Bagmati River

3.1.1. Station I (Up-stream)

This area is locally known as TikaBhairab (in the name of Hindu's Lord Bhairab). This location is out of Kathmandu Valley near TikaBhairab temple at the origin point of the river NakkhuKhola, with scattered population in a rural area and quite rich in natural resources (varieties of natural vegetation and striking landscape). This area is the confluence of LeleKhola and NalluKhola rivers, which join to form the NakkhuKhola River. Since this site is not much affected by development activities (except from

dust-road and bridge construction) or human population growth, the aquatic ecosystem in this region still maintains its natural condition and integrity, harmonizing with the existing natural environment.

3.1.2. Station II (Mid-stream)

This area is in the vicinity of agricultural land and human settlement known as Nakkhu Bazar. The location is Nakkhu Bridge nearly 15 kilometres from the mouth of the river, connecting Nakkhu Bazar and Bhaisepati areas. This area is newly developed urban settlement, densely populated compared to the up and down-stream areas. There are two carpet wool-dyeing and other pashmina-wool dyeing factories on either side of the river, several shops, small restaurants, meat shops, wood industries, poultry and temples etc. This site faces critical problems of several sorts of pollution, including industrial effluents (from carpet wool and pashmina dyeing), municipal sewage disposal directly (without pre-treatment) into the river, solid waste disposal, frequent washing of vehicles, floating debris and dead animal bodies, domestic sewage channel leading through agricultural land and then discharging into river.

3.1.3. Station III (Down-stream)

This is the confluence point of the River Bagmati and the NakkhuKholra River near Chobar, about 17 km from the origin. This area faces the problem of natural hazards, especially landslides during the monsoon period since one side of the riverbank is quite hilly terrain with few trees. The riverbank is erodible because high volumes of water cover large areas in the high flow period. About 500 m before the confluence is the Nakkhu Pump: here the water from river (before it gets contaminated in the mid-stream), that is about 13 km from the source, is extracted creating the underground channel and is collected at this Nakkhu Pump which is ultimately pumped into Sundarighat water pump for filtration and purification, it is then supplied to Kathmandu municipal the through Drinking Water Corporation.

3.2. Data Collection

Pre-designed questionnaires were administered with the help of local communities on water quality information. Efforts were made to collect information on the use of river by local communities, development activities and land-use practices through personal interviews, direct observations and informal discussions. The social survey was undertaken to investigate the local people perception and awareness about the river water pollution in terms of causes and consequences. The study was carried out by means of random sampling of a small number of people from each of the three stations. The total of 30 respondents (permanent residents of sampling sites up-stream, mid-stream and down-stream) both rural and urban people and 10 respondents (not permanent resident) of that area which included basically fishermen and factory workers residing away from the study area were included.

4. Results and Discussion

4.1. Social Survey Results

The responses were collected from the different categories of respondents residing around the three stations (up-stream, mid-stream and down-stream). The socio-economic study intends to complement the land-use change aims at understanding the current situation of resources and conservation. The study was carried out by means of random sampling of small number of people from each of the stations. The objective of the study was to assess the perception of local people concerning the change in the river over past decades and its effect upon them. In the present study male respondent were 60% and female 40% at the three stations. Regarding the age group the highest age group recorded 50% were that of between 30 to 40 in the mid-stream and 20% that of over fifty in the up and down-stream so, as to have the opinion of various age group people. With education level highest percentage (40%) of educated people were recorded in mid and down-stream and 40% without any formal education in the up-stream which signified that the up-stream was rural area compared to that of mid and down-stream and was not well exposed to educational facilities. For the statistical analysis, the responses are categorized into urban and rural population. The upstream population are categorized as urban and mid and downstream population as urban.

Table 1. Respondents' response about the principle uses of the NakkhuKholra

River use	Rural	Urban	Total
Agriculture	10	12	22
Fishing	5	3	8
Total	15	15	30

$N = 30$, $X^2 = 0.1705$, $df = 1$, $p\text{-value} = 0.6797$.

The survey showed that all people residing the up-stream used the NakkhuKholra river for agriculture i.e. for crop cultivation, whereas in the mid-stream and the down-stream (20%) gave no response, which showed that they had nothing to do with the river water, because most of people residing in that area were urban people who did not utilize the river water directly. Respondents' response regarding the principal use of the river, the result suggested no statistical difference between urban and rural population (Table 1).

Table 2. Respondents' response to the question about the waste disposal $N = 30$

Waste Disposal	Rural	Urban	Total
Riverbank	3	7	10
Private land	7	6	13
Road side	3	4	7
Total	13	17	30

$N = 30$, $X^2 = 3.8025$, $df = 2$, $p\text{-value} = 0.1494$.

All the interviewees disposed of their wastes (liquid and solid) on their private land in the up-stream station and lowest percentage (10%) adopted other methods such as by waste collecting system (provided by municipal) and roadside disposal. While comparing the sites, people residing up-stream disposed of their domestic wastes on their private land, as a part of the ecological cycle of domestic waste was still maintained and solid waste was not a problem in that area. People utilize the domestic

wastes as a form of organic fertilizers. This also because of sufficient land compared to that of mid and down-stream. Respondents' response were categorised into industrial effluents and other (which included sewage, industrial/domestic wastes, washing and bathing of animals). However, the difference between the urban and rural population response was not statically significant (Table 2).

Table 3. Respondents' response about the causes of the NakkhuKholapollution N=30

Causes of river pollution	Rural	Urban	Total
Industrial effluents	0	3	3
Other	10	17	27
Total	10	20	30

N= 30, $X^2=1.5686$, $df = 1$, $p\text{-value} = 0.2104$.

Responses regarding the causes of river pollution showed variation within the respondents residing in the three stations. According to mid-stream respondents, the main cause for the river pollution was due to unplanned domestic sewage system, solid waste disposal and industrial effluents, which were directly discharged into the river without prior treatment. According to 60% respondents' up-stream the actual cause of river pollution was because of construction activities (dust-roads, bridges etc.). About 20% of respondents of the three stations did not respond because they did not have any idea about pollution and water quality. Which mean that these people were not aware of river pollution that might be because they lived at some distance from the river, or they were not directly dependent upon river water, however, there the difference in response was not statistically significant (Table 3).

Table 4. Respondents' response towards concern about river pollution N = 30

Responses	Rural	Urban	Total
Yes	8	12	20
No	2	8	10
Total	10	20	30

N= 30, $X^2=0.4687$, $df = 1$, $p\text{-value} = 0.4936$.

The highest percentages 80% (up-stream) of respondent were concerned about the NakkhuKholapollution and only the lowest i.e. (10%) mid-stream and down-stream were not sure about their concern and 20% (up-stream) and 30% (mid and down-stream) was not at all concerned about it. This showed only very small percent of respondents were not aware of river pollution and that high percentage was aware of what was going wrong with the river. So, it could be said that they were aware but their awareness was not translated into actions, which could be done, if the effective implementation regarding translation of awareness into action is carried out with the help of effective institutions. Respondents' opinions regarding increase in farm productivity varied. About 100% of up-stream and 60% of down-stream respondent reported that increase in farm productivity was because of river water and fertilizers. About 20% of respondent (mid-stream and down-stream) said that it was because of sewage water, which is rich in nutrients. They also believed that river water alone did not give the output they expected. Among all the respondents those residing in the up-stream all (100%) were aware of kinds of creature

found in the river. This was because the people residing in that area were frequent users of the river water for example, pebble collection, washing, bathing, swimming, fishing etc. Similarly, that of mid-stream 60% was not at all aware of such creatures because people were not at all dependent on it or in contact with them.

Table 5. Respondents' answer to the question, "Do you value these creatures"? N = 30

Responses	Rural	Urban	Total
Yes	8	9	17
No	2	11	13
Total	10	20	30

N= 30, $X^2 = 2.0532$, $df = 1$, $p\text{-value} = 0.1519$.

Up-stream respondents did realize the importance of creatures found in the river whereas those residing in the mid-stream and down-stream did but the difference was not statistically significant (Table 5). This might be because these people were not much dependent upon the river resource. The survey also showed that all (100%) of respondent reported that there was not any pollution control authority working towards river pollution control in the three sampling stations, which showed the negligence towards the river conservation. Apparently, there was lack of rules and regulations related to waste management. Even though the local and central leaders of all political parties frequently repeated the slogan of "Clear and Green Kathmandu", but had failed to translate this slogan into any form of action. The survey also found out that all respondents reported that the river water was drinkable 30 years back but now is just for agriculture and watering livestock and other domestic activities (washing, bathing etc.).

None of the respondents were now dependent upon the NakkhuKholapollution drinking water. Villagers working or residing nearby only used the river water. The NakkhuKholapollution river water was the source for both watering livestock and irrigation while the bathing and washing were also frequently undertaking activities. From this social survey it could be stated that local people residing in the study area those of the up-stream were more concerned about the NakkhuKholapollution river pollution because people in that area were more dependent in the river water compared to that of other stations. They even reported that the water of this river was drinkable about 20 years back but now it was used only for raising crops (irrigation) and watering livestock, washing and bathing. According to these people, the main reason for water pollution was due to construction activities (roads and bridges) and erosion of the riverbank. One farming couple interviewed reported they preferred the sewage water to river water, since they did not have to buy nitrate and urea fertilizers. Thus, the farmer up-stream irrigated with river water, while their counterparts mid-stream had some source of nutrient-rich wastewater. It was also observed in the mid-stream the leakage of municipal sewage pipe. Local people (relatives of the local politicians) have had "broken" the pipe to get its contents by which they irrigate and raise swans and ducks for their individual benefit no matter it was creating non-hygienic environmental condition to its neighbour. Down-stream respondents were to some extent dependent on the NakkhuKholapollution for agriculture. People in that area also used this river for fishing (not for the commercial use

but for their own consumption) and they reported about the fish kill. In this area respondents were most of them farmers and some of them also reported that flow discharge of the river was high during the high flow and increased in riverbank erosion was identified as a particular problem. The water was extracted from the region between the up and mid-stream and was brought through the channel to pump the water into the Nakkhu Pump (situated near the confluence of the NakkhuKhola and river Bagmati) then to Sundarighat in Kirtipur, Kathmandu, where it was treated and was supplied to Kathmandu Municipal Drinking Water Corporation. These people also reported that water coming from mid-stream was in worse condition because of sewage contamination. The people even reported that river water was used only for watering the livestock and sometimes even for drinking when the tap was dry and there was no alternative source of drinking water. In fact, none of the respondents were entirely dependent for drinking water upon the NakkhuKhola. The non-resident respondents of the study area were fishermen and factory-workers (mid-stream) did not show much concern regarding the water quality of the NakkhuKhola. According to fisher folk (number of full time fisher-folks were small) there were varieties of fish species present in the NakkhuKhola. Their population and sizes were larger in the up-stream than mid and down-stream, but they were not actually aware of the effects of pollution in the river although few reported the reason for the reduction of fish species was due water quality. Similarly, with the factory-workers they were not serious on their practices. According to the owner of the factories, they were not only the factor for causing for river pollution: one of them in their interview even reported that people from higher authority collected money from them for establishment of the effluents treatment plant and repairing for the municipal sewage channel but after that they never reappeared. These people also reported that these factories were installed far from the capital city (Kathmandu) and thus, the pollution emitted was diluted in the air and water. For them, this problem was not considered as individual, so it could be solved collectively by the involvement of the local people and local level authority, but there was missing-link between local people and local authority. One interviewee also said "This River will never be cleaned; it is useless that you people want unnecessary details from us and we don't have time for all these rubbish questions".

4.2. Findings of Social Survey

The respondents of mid-stream site did not show much care about the water quality as per these people who were not directly involved with the water uses. It was also found that these people were aware that water quality was degraded and it was getting worse day by day, but still they could not do anything, which proved that only being aware was not effective unless it was translated into action. The problem of pollution was observed due to rural land being absorbed into growing cities area. The NakkhuKhola pollution problem was a recent one, a couple of decades back the river was in its natural condition. However, the problem of pollution arose due to new-urban area expansion and factories installation. If the unplanned residential areas went on increasing, the

agricultural land which at present acts as constructed wetlands (natural treatment for domestic wastewater by adsorbing nutrients) would go on decreasing and ultimately there would be insufficient land left which would act as natural treatment system. This would increase the surface run-off of wastewater directly into the river disturbing its natural assimilative capacity resulting in a biologically dead river as the case of the River Bagmati. However, if this sort of land use trend is followed, and municipal is not active in implementing mechanisms to set up standards for factory effluents treatment, the river water quality would become worse and would become biologically dead. The flow rate of small urban rivers has been decreased due to the expansion of open sewage collecting systems as in the mid-stream area. This resulted into a shortage of river water necessary to dilute the inflow of pollutants. The NakkhuKhola water intrusion into the Bagmati River would cause improvement of river water quality. If the continuation of urbanization was unchecked, unregulated and unplanned industrial installation was not restricted and treatment plant was not installed, the natural assimilative capacity of the environment (water and soil) would be disturbed and degraded, hence would lose its productivity. The study found out that river was still productive and it supported a large number of fish species. If some effort was to be carried out and maintained to introduce cleaner production system and to treat industrial pollution, the river would again improve its condition because the river retains its assimilative capacity, and could contribute to cleaning our Holy River Bagmati. Such type of actions on a large scale is recommended for other tributaries of the Bagmati River. It was also noted that many local organizations were aware of the problem and that they were contributing to it in some way, but was unable to tackle it individually. Industries were concerned with production, and effluents control was low priority; they may respond a little to public criticisms, but so far this was a very small movement. They also felt that they were not significantly responsible for pollution problem. A dominant belief in many communities was that the problem was caused by a failure of government – a lack of planning, regulation and enforcement and failure to implement projects appropriately and effectively and should be therefore solved by government. Despite this, people feel that enforcement of any controls would be exceptionally difficult and they had little confidence that the existing institutions would be able to perform better on future projects. Many said that the failure to consult the public was a key reason for these factors, but conversely many people said that there was no point in talking to government because it could never be delivered. It was also observed that there appeared neither to care for the river nor to conserve it, judging by littering in open place and riverbanks. People recognized that there were problems in their present attitude towards waste disposal and that they were not fully responsible in their behaviour. However, at the same time they felt that they were only one of the contributors. They felt that their contribution was less than the government bodies, which allowed untreated sewage to be discharged into the Bagmati and its tributaries. They believed that they were less guilty than the carpet factories, which discharged chemically, polluted industrial effluents untreated directly into the river. The

survey also found out that people believed that bureaucratic performance including the problems of coordination was the main issue. This made them sceptical of any government action and thus there was distrust between the people and government. Awareness of the problem, however, did not appear to lead to it be tackled and resolved. This missing link between awareness and action was typical of unregulated, unorganised and confused. Finally, there would appear to be nothing inherent in which would prevent better use and management of resource and cleaning-up settlements. But there were substantial knowledge, understanding and attitudinal gaps and problematic practices in households, communities, institutions, government agencies, commercial establishment and also among visitors. If this gap to be bridged, an approach must be adopted which encouraged the people to understand and address the problem using their own resources wherever possible. Positive initiatives should be supported and encouraged. The strengthening of community organization, encouragement of local responsibility and mobilization of local resources could be the precursor to effective action. Thus, public awareness and river pollution control could be effective only by the public participation action, each individual contribution in river cleaning process, convincing people to value the natural resources, serious involvement of local government to work hand in hand with local people, reconstruction and monitoring of public, hospitals, factories, hotels etc. sewage and drainage channels and pipes, setting industrial standards and its implementation.

4.3. The Major Environmental Issues Identified in the Study Area

- Conversion of fertile agricultural land into urban area
- Increase and unplanned urbanization and industrialization
- Declining aquatic biodiversity
- Disposal of untreated wastewater into natural water bodies
- Dumping of solid wastes in rivers and open lands
- Lack of adequate legal framework and institution for management and control of deteriorating condition of the natural resources
- No legal provision on land-use management
- Absence of both municipal and industrial effluent standards
- Weak enforcement of existing legal provisions and their monitoring
- Lack of integrated institutional structure.

4.4. Field Observations

The field survey investigated that domestic effluents in the area between mid-stream and down-stream were directly discharged into rice fields (the major crop in the agricultural land during my field survey). Most of households did lack soak-pit to collect wastewater in their home garden.

All these domestic effluents were directly discharged into the agricultural land and ultimately into the river. In spite of domestic sewage and agricultural runoff (point and non-point source pollution), the water quality at the down-stream station was better than the mid-stream (post-

monsoon). This could be due to adsorption of the soil or sufficient uptake by plants and also due to the bacterial activities and decomposition. This might be also because of the soil infiltration and adsorption, since most of the nutrients and organic matter are reduced (80-90%) after water has flowed through a very limited volume of soil (Jenssen, 1997). Rice and other crops absorbed the nutrients from the domestic effluents and soil infiltration, which resulted into the seepage of ground water free from nutrients, so did not contributed in adding pollution load into the river, and instead acted as a dilution factor. The river flowing between mid-stream and down-stream was at a lower altitude than residential areas and agricultural lands hence the dilution effect from ground water seepage might have contributed towards diluting pollutants of the NakkhuKholariver. In the sloped terrain, the soil acts as an infiltration system (Jenssen, 1996). Various biological and chemical reactions occurring in the river might also have contributed in the bacterial decomposition of organic matter into inorganic form contributing in reducing the pollution load from the river.

4.5. Fishing

Apart from irrigation, the river was also used for fishing. The fisherfolk were generally not inhabitants of that area used their traditional fishing gear a round-shaped cast-net known as "Jaal". One or several persons operated the net according to its size. It is used in plane waters of Terai (low land) and valley where the water is slow]. Existence of varieties of fishes such as *Acrossocheilus hexagonalepis*, *Garra spp.*, *Channa spp.* and *Puntius spp.* were reported by the local fisherfolk. They also stated that the fish size was larger and population density higher in the up-stream than those of mid and down-stream.

4.6. Stone Collection

The collection of stones and pebbles from the banks and beds was a common activity particularly in the up-stream area. Generally, women and children were involved in this practice. The stones were crushed and used for construction purpose to meet the growing demand of the urban population.

4.7. Washing and Bathing

The river was used for washing (clothes, utensils and vehicles) and bathing of animals and human beings. The river was more commonly utilised for vehicle washing in the mid-stream area. Different kinds of vehicles were washed every day in the river. In addition, one could see the frequent washing of the carpet-wool taking place.

4.8. Solid Wastes Disposal Site

The riverbank of the NakkhuKholariver, especially that of mid-stream, was found to be a common place for the solid waste disposal (photo 3) generated by households and other land-use practices (motels, wood industries, carpet industries, temples, shops, etc.). This kind of disposal was not so common in the up-stream area. The up-stream systems used the organic waste produced by domestic use as fertilizers. This ecologically maintained system of organic wastes being used in farms was found lacking in the mid-stream due to rapid growth of urban

population resulting in the demand for land for housing increased thus causing decrease in the farmland.

At the same time use of the inorganic fertilizers in the farming system was increasing because of modernization, thus the traditional occupation of collecting domestic wastes carried out by the occupational castes could hardly be seen. All these factors caused a drastic decrease in the demand of domestically produced organic fertilizers. This created a system in which the domestic wastes had to be disposed directly/indirectly into river through sewerage network system or riverbank disposal system. The growth in urban population also increased the amount of solid waste disposal. Solid waste dumping was more common in mid-stream and down-stream areas compared to the up-stream area of NakkhuKhola.

4.9. Ritual Uses

Rivers are holy places and temples of Gods and Goddesses are erected on their banks or at the confluence point of two or more rivers. They are important locations for cremation. During the religious festivals of great importance, crowds of pilgrims gather around the temples to offer due respect and animals sacrifices to Gods and Goddesses. The religious goods, statues, portrait of Gods and Goddesses are washed or released into the NakkhuKhola at the end of the religious ceremony. The NakkhuKhola river bank was not exactly the cremation place but the ashes are washed down into the river after it has been cremated in the Bishnudevi Temple situated approximately 300 m from the river bank. Human corpses are cremated at the side of the river according to Hindu religious tradition.

4.10. River Water Uses, Pollution and Public Awareness

The present study found that none of the communities were fully depended on the NakkhuKhola for drinking water although was this the case 20 years back. The river was still used for irrigation, watering livestock, and washing. However, for none of these uses was it the preferred source of water and alternatives are used where available. Apart from these uses the river is used for industry (for washing wool and carpets), sewage and effluents disposal, recreational fishing, stone collection, washing of clothes and utensils, vehicles and bathing of animals and human beings, disposal of solid wastes and for ritual uses. All these river use activities were in one or another sources of pollution. Social survey found out that people were aware of the pollution and also about the cause and effect of it but their awareness was not yet translated into action. This was apparent because of local authorities' negligence and lack of effective implementation, monitoring of existing rules and regulation. This was also because of political instability. Apart from this there was missing-link between local government and local people. If just a small effort would be taken by local authorities in establishment of water quality and standards monitoring of industrial effluents with sanction provisions, these small rivers that are still productive would maintain their assimilative capacity and to some extent help in cleaning the heavily polluted Bagmati River. If pollution is unchecked and domestic and industrial effluents are allowed to be discharged into the river without treatment

then we will not be far from the time when all these small tributaries will resemble the Bagmati River and the Kathmandu valley will be no better than garbage dumping site. Thus, the scientific findings of this report and other such reports (WESC, 1997; Pradhan, 1998, NESS, 1998 and Shakya, 2000) should be actively used by authorities responsible for water quality and pollution control action.

4.11. Effects of Land-use on Water Quality

There are several studies, which showed there was a relationship between land-use and water quality Dukson (1990), IBE & Njemanze (1998) Ometoet *et al.* (2000), Field *et al.* 1996) etc. The changes in land-use result as rural land become absorbed into the urban area or growing cities and this ultimately have an impact on the adjoining river water quality. Twesigyeet *et al.* (2011) study of the physical and chemical analysis of water quality revealed high levels of phosphates and nitrates along the agricultural zones of River Nzoia Basin. Furthermore, he results from effluent analysis showed that the effluents from the industries are not adequately treated and therefore, impact negatively on the quality of the receiving waters. The present study on the land-use reflected that in the up-stream, the water quality was better as compared to the mid-stream and down-stream even during the post-monsoon period. This area was less influenced by land-use because a large portion of land was used for agriculture. In turn, in the mid-stream where the large portion of the area (almost 60%) was occupied by settlement and semi-urban area (30% build up area) the water quality was poor in this area compared to the up-stream. Similarly in the down-stream, which was comparatively improving compared to that of mid-stream, reflected that the area was somewhat less influenced by the urbanization and industrial effluents. This also showed that river water quality flowing in the area where there was large agricultural land and less settlement area was in better condition than that of flowing through the urban area, the findings of Lenat and Crawford (1994) also supported this result.

4.12. Effects of Pollution on People

- Considerable evidences were collected during the social survey showed how a decline in water quality over the years has affected people lives. River water was still used for irrigation, watering livestock, drinking and washing. However, for none of these was it the preferred source of water and alternatives were used where available. The development of these alternatives had been accelerated by the decline in water quality and now no communities were found to be entirely dependent upon the NakkhuKhola as was the case 30 years back.
- The vicinity of mid-stream area, which was newly, established urban area suitable for residential area but due to increasing pollution, activities (washing vehicles, open defecation, domestic/ industrial effluents channel into the river, debris and dead animals floating) were creating negative impact on the surrounding environment. If these activities were unchecked, they would increase day by day ultimately resulting into the condition when the river would cross its assimilative capacity and would become biologically dead.

5. Recommendations

- Detailed and participatory studies of tributaries of the Bagmati River should be carried out with long-term objectives and towards action plans. Similarly, in-depth scientific studies in relation to the environmental impact of changes in land-use on water quality should be carried out.
- Low-cost treatment plants for industries should be established in the vicinity of factories, especially if they are situated near the riverbank. Cleaner production technologies should be introduced (reducing, re-using and recycling wastes).
- Land for small-scale solid waste treatment should be reserved and acquired at locations away from the riverbank so that solid waste should be collected and deposited at these locations.
- Small lagoon areas with varieties of nutrient adsorbing plant species for natural treatment should be established for uses in circumstances of liquid waste from domestic sewage disposal.
- There is an urgent need for national level wastewater treatment standards for industrial effluents and setting effluents standard and steps should be taken by relevant authorities
- Regular and scientific monitoring of river water quality of Bagmati River System be initiated and maintained.
- Technical reports submitted to local authorities should be discussed orally without using difficult technical terms. Otherwise, after a quick look, such reports may be placed on the shelf to be forgotten. In such situation, feelings or impressions that are subjective judgments may overshadow scientific results.
- People living in and around the area under investigation should be completely informed about what is being done and the reason for doing it. If possible, they should be drawn into the project in various ways; for example, by letting them express their own ideas and beliefs. It would also be of advantage to give brief, simple reports to the schools and youth clubs.
- Additionally, Miramanda, Bustamantea, Bentleya, & Kouétac, (2006) in their study indicated mercury contamination in cephalopods in marine environment and found that cephalopods could be a very good indicator of Ag contamination in the marine environment. Future study is recommended using Cephalopods as pollution indicator.

6. Conclusions

Human interventions have greatly decreased the natural spatio-temporal heterogeneity and disrupt major interactive pathways, which results in the reduction of in the structural and functional integrity of freshwater ecosystems. The main change in rural land-use occurs where it is absorbed into the growing cities and towns. This conversion to urban land has a negative impact on river water quality, especially because of the location of industrial developments, much of which occurs alongside

the environmentally vulnerable rivers. The impact of existing and projected future rural land-use on river water quality is relatively small. From an environmental point of view, urban growth is the critical aspect of land-use change. Earlier there was a buffer strip of agricultural land between the cities and the river, hence the irrigation of this land absorbed the small amount of urban wastewater and the rivers remained relatively clean, but such buffers are becoming diminished. More wastewater is now produced and almost all of it pollutes the river since the agricultural land is declining and there is less agricultural land to irrigate. In the present study it was observed that the river up-stream which was the rural area with higher proportion of agricultural land had better water quality compared to the mid-stream river water quality subjected to the urban influence i.e. direct discharge of municipal and industrial effluents into the river and several other polluting activities around and into the river such as solid-wastes disposal, washing of vehicles, floating debris and dead animals bodies etc. However, the river water quality down-stream was comparatively better than at mid-stream due to the dilution of pollutants as a result of soil-infiltration, adsorption, plant up-take and ground water seepage and also bacterial breakdown of organic wastes and oxidation processes. Survival of science as a profession is closely related to the effectiveness of its practice in the everyday life of the society. Lack of adequate scientific concepts and lack of public awareness has a great influence on the management of natural resources. The lack of effective policy concerning protection of water resources also contribute to the lack of community contribution in solving the environmental problems. Non-governmental organizations for creating public awareness regarding pollution control are young in Nepal, yet they are beginning to have some impact. Local organizations and communities still rely on the government to take the responsibilities to solve these kinds of problems. Industries are concerned with production and environmental concern is given low priority, they are responding a little too public criticism. They also feel that they are not adding significant to the existing problem.

Acknowledgements

The author would like to that Dr. Bryson for his valuable input in completion of this work.

References

- [1] Bartram, J. & Balance, R. (1996). (Ed.) Water Quality Monitoring: A Practical Guide to the Design of Freshwater Quality Studies and Monitoring Programme. Published on behalf of UNDP & WHO Chapman & Hall, London. 383 pp.
- [2] Canter, L. W. (1985). River Water Quality Monitoring. Michigan: Lewis Publisher, Inc 165 pp.
- [3] Davis, S. & Simon, T. P. (1995). (Ed.) Biological Assessment and Criteria Tools for Water Resource Planning and Decision Making. Lewis Publisher, 7-14 pp.
- [4] Dixit, S. S. (1998). Evaluation of Water Pollution of Bagmati River in Kathmandu Valley and People Awareness of the Problem. M.Sc. Unpublished Thesis. Agricultural University of Norway, Ås NLH. 71pp.
- [5] Dukson, D. W. (1990). Land Use and Water Quality-Relationships in the George Creek Basin, Maryland. Water Resources Bulletin, American Water Resources Association, 25: 801-807.

- [6] EISP /HMG (1987). Environmental Impact Assessment of Bhrikuti Paper Mill, EISP, Nepal. 72 pp.
- [7] Field, C. K., Siver, P. A. & Lott, A. M., (1996). Estimating the Effects of Land-use Pattern on Connecticut lakes. *Journal of Environmental Quality*, 25, 325-333.
- [8] Twesigye, C. K., Onywere, S. M., Getenga, M. J., Mwakalila, S. S & Nakiranda, J. K. (2011). The Impact of Land Use Activities on Vegetation Cover and Water Quality in the Lake Victoria Watershed. *The Open Environmental Engineering Journal*, 4, 66-77.
- [9] GoN/NTNC (2009). Bagmati Action Plan (2009-2014), Kathmandu, Nepal.
- [10] HMG/ ICIMOD/ CDG/ UNEP, 1994. Geological Maps of Nepal. Kathmandu. Department of Mines and Geology. 146 pp.
- [11] IBE, K. M. & Njemanze, G. N. (1998). The Impact of Urbanization and Protection of Water Resources in Owerri and Environs se, Nigeria. *Environmental Monitoring and Assessment* 58, 337-348.
- [12] Jenessen, P. (1996). Ecological Engineering for Wastewater Treatment: Fundamentals and Examples. *Environmental Research Forum*, 6, 215-220.
- [13] Kadlec, R. H & Brix, H. (Ed) (1995). Wetland Systems for Water Pollution Control. Proceeding of the 4th International Conference. *Water Science Technology*. 32: 3.
- [14] Lenat, D. R. & Crawford, J. K. (1996). Effect of Land-use on Water Quality and Aquatic Biota of North Carolina Piedmont Streams. *Hydrobiologia*, 249, 185-199.
- [15] MPE (2000). Ministry of Population and Environment, Kathmandu, Nepal. Annual Report, 2000.
- [16] Miramanda, P., Bustamantea, P., Bentleya, D., & Kouétac, N. (2006). Variation of heavy metal concentrations (Ag, Cd, Co, Cu, Fe, Pb, V, and Zn) during the life cycle of the common cuttlefish *Sepia officinalis*. *Science of the Total Environment*, 361, 32-143.
- [17] NESS, (1997). Environmental Studies of the Bagmati Watershed & Mitigation of River Pollution. Nepal Environmental and Scientific Service (P) Ltd., Kathmandu, Nepal.
- [18] Ometo, J. P., Martinelli, L. A., Ballester, M.V. Gessner, A. Krusche, A.V., Victoria, R. L, Williams, M., Jean. H. B. Pierre (2000). Effect of Land -use on Water Chemistry and Micro Invertebrates in two Streams of the Piracicaba River Basin. *South East Brazil. Freshwater Biology*, 44, 327-337.
- [19] Pradhna, B. (1998). Water Quality Assessments of the Bagmati River and its Tributaries, Kathmandu Valley, Nepal. Ph.D. Thesis. Department of Hydrobiology, Institute of Water Provision, Water Ecology and Waste Management, Universitat fur Bodenculture, Vienna, Austria. Unpublished thesis 188 pp.
- [20] Sivaperumal, P. & Sankar T.V., Viswanathan Nair, P. G. (2007). Heavy metal concentrations in fish, shellfish and fish products from internal markets of India vis-a-vis international standards. *Food Chemistry*, 102, 612-620.
- [21] Shakya, S. K. (2000). Water Pollution in the Urban Rivers of Kathmandu, Nepal: A case study of water quality assessment and wastewater treatment requirements. Ph.D. Thesis, Department of hydrobiology, Fisheries and Aquaculture, Department for Sanitary Engineering and Water Pollution, Institute for water Provision, Water Ecology and Waste Management, University of Agricultural Sciences, Vienna, Austria. Unpublished thesis, 215pp.
- [22] Shah, B., 2009: Environmental Implications of Urban Water Front Transformation: A Study of the Sankhamul Teku.
- [23] Stretch in Kathmandu in Spaces.
- [24] Singh, H., Mishra, J. P. & Mahaver, L. R. (1998). Observation on Certain Physio-chemical Characteristics of Water Pollution in Relation to Pollution of river Ramganga. *Journal of Environmental Biology*, 19, 353-356.
- [25] Singh, H., Mishra, J. P. & Mahaver, L. R. (1999). Impact of Industrial and Sewage Wastes on Water Quality in Middle Stretch of River Ganga from Kanpur to Vanarasi, India. *Journal of Environmental Biology*, 20, 279-283.
- [26] Turner, B. L. & W. B. Meyer. (1993). Land use and land cover change: Consideration for study. *International Journal of GIS*, 1, 77-87.
- [27] Ward, J. V. (1989). Riverine Wetland Interactions. *Freshwater Wetland and Wildlife*, Conf-8603101, DOE symposium Series 61, Shritz and J.W. Gibbons (Ed) USDOE Office of Scientific and Technical Information, Oak Ridge, Tennessee.
- [28] WESE (1997). Water Energy Commission Secretariat. Final Report, "Environmental Study of the Bagmati Watershed and Mitigation of the River". NESS, Kathmandu, Nepal. 526 pp.