Solid Waste Management in the city of Kathmandu, Nepal

Evaluation of the Växjö Risk Assessment Model applied on Gokarna Landfill Site

Christina Anderzén & Veronica Blees

Department of Technology
University of Kalmar
SE – 391 82 Kalmar

Supervisor at the University of Kalmar: Professor William Hogland
Supervisor at Development Network Pvt. Ltd., Kathmandu, Nepal: Mr. Dinesh R. Manandhar

Programme of Environmental Engineering
Final thesis 10p

PREFACE

Rapid population growth and urbanization in developing countries have led to the generation of large quantities of solid wastes and consequential environmental degradation. 90-95% of all waste in the world is landfilled or disposed in open dumps, creating considerable nuisance and environmental problems. Often lack of technical knowledge, financial and human resources coupled with existing policies limit the extent to which landfills can be built, operated and maintained at minimum standards of sanitary practice (AIT).

UN conference in Johannesburg, 2002 declared that there will be a lack of water in big parts of the world before the middle of this century. Landfill leachate contributes to long-term effects by polluting surface and ground water, limiting the access to clean drinking water. Leachate may be defined as liquid that has percolated through solid waste and has extracted dissolved or suspended materials.

Landfills are a source of methane and carbon dioxide emissions, which are greenhouse gases and a major threat to nature. The Kyoto protocol shows that landfill gas will constitute 4% of the total emissions of greenhouse gases in 2010. The protocol, that aims to decrease the emissions of greenhouse gases, was signed by the EU-countries and other industrialized countries in 1997.

In Asia incineration is traditionally used to get rid of large volumes of waste. The development in the Asian countries have resulted in a change of the waste characteristics and the uncontrolled incineration leads to environmental and health problems. Controlled incineration demands expensive technology that is difficult to maintain in developing countries.

The rapid population growth and urbanization in developing countries as Nepal constitute a threat to the environment. Along with the development comes the problems with solid waste and the situation in Kathmandu is at the moment precarious. The environmental problem caused by improper solid waste management in the expanding cities is one of the most urgent improvement issues for the government of Nepal.

The environmental implication of solid waste management failure has resulted in the decline of health and hygiene conditions of a growing population. Nepal and especially the capital Kathmandu are today going trough rapid changes and the urbanisation is going fast. The urbanisation result in more waste and concurrently the development result in new life patterns, standard of living and attitudes change the composition. New industries are erected that changes the waste composition to include more and more hazardous waste.

The situation in Kathmandu is not representative for whole Nepal but if the developing problems that are connected with solid waste are not taken care of further urbanisation will most likely give similar scenario in other growing cities.

As the final thesis of the Environmental Engineering Program, University of Kalmar, Sweden, this study was financed by two Minor Field Studies-scholarships from the Swedish International Development Cooperation Agency, Sida. The research was carried out parallel and in close co-operation with the Sida project “Characterisation of pollutants from city dump/landfill in Kathmandu valley, Nepal, and preliminary studies on technical measures for their reduction” that started up during 2003 in Kathmandu, Nepal.

The study is meant to give practice in field work, international co-operation and transfer of knowledge. International co-operation is necessary to secure a sustainable solid waste management and development. The main task was to make a survey of the situation in Kathmandu to be able to identify in what areas further studies should be focused. The results will be of use for developing a proper solid waste management in Kathmandu.

FACTS ABOUT NEPAL

Full country name	Kindom of Nepal (AIT)
Constitution	Monarchy (Ui, 2002)
Language	Nepali, English (AIT)
Government	Parliamentary democracy (AIT)
Head of State	King Gyanendra Bir Bikram Shah Deva (AIT)
Head of Government	Prime Minister Surya Bahadur Thapa (AIT)
Religion	Hindu 86%, Buddhists 8%, Muslims 4%, others 2% (Ui, 2002)
Current political status	Instable due to hostility between the Maoist guerrilla and the government

Economy and labour market	
Monetary unit	NPR (Globalis) 1 Rupee = 100 Paisa (Ui, 2002)
BNP per capita	220 US dollar (Ui, 2002)
Annual Growth	6% (AIT)
Major Industries	Tourism, carpet, textile, small rice, jute, sugar, oilseed mills, cigarettes, cement and brick production, rice, corn, wheat, sugarcane, root crops, milk, water buffalo meat (AIT)
Natural resources	Forrest, Hydropower, Quartz, Lignite, Copper, Lead (Ui, 2002)
Main export countries	India, USA, Germany, China (Ui, 2002)
Main import countries	India, Singapore, Japan, China (Ui, 2002)
Percentage employed in different branches of industries	Agriculture 81%, Service branches 16%, Industry 3% (Ui, 2002)
Unemployment	5% (officially, but almost half of the population can not earn their living) (Ui, 2002)
Population living below $1 per day	37.7 % (Globalis)

Geography and climate	
Area	147 181 km^2 (Ui, 2002)
Neighbouring countries	Indien, China (Ui, 2002)(AIT)
Capital	Kathmandu (Ui, 2002)(AIT) with 671846 inhabitants (Brinkhoff, 2001)
Average temperature/ day and night	Kathmandu Valley 25ºC (Jul), 10ºC (Jan) (Ui, 2002)
Average rain/ month	373 mm (Jul), 3 mm (Dec) (Ui, 2002)

Population	
Population	26.46 million (AIT)
Population/ km^2	172 (Ui, 2002)
Average population growth rate	2.2 % (2000- 2005) (Globalis)
Calculated average lifetime	Men 59, Women 58 (Ui, 2002)
Population under 15 years old	40.5 (Globalis)
Total fertility rate	4.26 Average number of children (Globalis)
Urban growth rate	6.5% (KMC, 2003)
Urban population	12.2% (Globalis)
Adult literacy rate	42,9% (Globalis)
Youth literacy rate	61.6% (Globalis)

Environment	
Ecological footprint	0.83 Global hectares per person (Globalis)
Land area covered by forests	27.3% (Globalis)

TABLE OF ABRIVATIONS

AEF – Assessed Environmental Factor
AF – Assessment Factor
AIT – Asian Institute of Technology
AMDIS – Automated Mass Spectral Deconvolution & Identification System
BMZ – Federal Ministry for Economic Co-operation and Development
BSc – Bachelor of Science
CBO – Community Based Organisations
CEF – Calculated Environmental Factor
CMU – The Community Mobilization Unit
DOC – Dissolved Organic Carbon
EF – Environmental Factor
GTZ – German Agency for Technical Co-operation
HALS10 – Hole A, L/S 10
HALS2 – Hole A, L/S 2
HBLS10 – Hole B, L/S 10
HBLS2 – Hole B, L/S 2
JICA – Japanese International Cooperation Agency
KMC – Kathmandu Metropolitan City
L/S 10 – Liquid/Solid ratio 10
L/S 2 – Liquid/Solid ratio 2
LAQUA-group – Leachate aqua group
LNC&F (P) Ltd. – Luna Nepal Chemicals & Fertilizers (P) Ltd.
MFS – Minor Field Study
NESS – Nepal Environmental and Scientific Services (P.) Ltd.
NGO – Non-Governmental Organisation
NH_4-N – Total nitrogen
NS – Number of Significance
PCBs – Polychlorinated Biphenyls
P-tot – Total phosphorous
Sida – Swedish International Development Cooperation Agency
SPE-disc – Solid Phase Extraction disc
SVOC – Semi-Volatile Organic Compound
SWM&RMC – Solid Waste Management and Resource Mobilization Centre
TNS – Total Number of Significance
TOC – Total Organic Carbon
UI – Utrikespolitiska Institutet
UN – Uncertainty Number
WHO – World Health Organisation

ABSTRACT

The rapid population growth and urbanization in developing countries as Nepal constitute a threat to the environment. The urbanisation result in more waste and concurrently the development result in new life patterns, standard of living and attitudes change the waste composition. New industries are erected that changes the waste composition to include more and more hazardous waste. Along with the development comes the problems with solid waste and the situation in Kathmandu is at the moment precarious. The environmental problem caused by improper solid waste management in the expanding cities is one of the most urgent improvement issues for the government of Nepal.

The main objective of this study was to make a survey of the conflicts of the solid waste management in Kathmandu and to identify issues for further investigations. The work was focused on Gokarna landfill site and the dumping of solid waste at Balkhu, along Bagmati River.

To investigate the current situation in Kathmandu field studies and visits were carried out both at Gokarna landfill site and the present dumping site along Bagmati River as well as interviews with people involved in the solid waste management in Kathmandu. The results of the survey showed that co-operation between the municipality, governmental institutions and the private sector that do not exist today are necessary to enable improvements of the solid waste management. Additionally environmental laws and regulations with proper enforcements are needed. It came clear that education of the people in environmental issues such as solid waste management is essential to increase the environmental awareness and improve the situation.

To clear what threat the sites constituted to the surroundings the water quality and the waste compositions were investigated. The water quality analysis of water samples taken in Bagmati River upstream and downstream the dumping at Balkhu showed that the water was heavily polluted, though further investigations are needed to clear to what extent the dumping at Balkhu contributes to the pollution. Literature studies showed that the pollution of Bagmati River has increased during later years.

A handpicking analysis was carried out on one tonne of waste for dumping at Balkhu showed that the organic fraction was as high as 67 %. Proper waste separation in combination with a compost plant in Kathmandu would greatly reduce the volume of waste for landfilling. Laboratory studies showed that the waste contains metals as well as heavy metals that eventually will leak out to the surroundings. Since the site does not have any fundamental protective structure, the dumping at Balkhu is considered to constitute a serious environmental threat that can not continue.

A model, developed by Växjö municipality, Sweden, was used as a checklist and structural model for inventory and risk assessment of the terminated Gokarna landfill site in Kathmandu to investigate the possibilities of using the model in future environmental inventories and risk assessments of old landfills in developing countries. The model showed to be useful in developing countries since the so-called number of uncertainty enable carrying out the inventory and the risk assessment even though expertise, information, lab facilities etc. are insufficient in the country. Since the model is meant to be used with a minimum of resources it is interesting to use in a developing country such as Nepal. The way the model investigates which landfill/dump that causes the worst environmental impact it gives the possibility to use available resources where they are most needed. By experiences interviews and field visits appear to be the most useful and feasible methods of collecting informative data for the investigation.

Results from the water quality investigation, field visits and interviews were used in the investigation, following the Växjö risk assessment model, to eventually classify Gokarna landfill site as 2 (B) i.e. further investigations are needed to clear if the site constitutes a concrete environmental conflict. By comparing different solutions for the terminated Gokarna landfill site it came clear that a proper closure with possibly cover and treatment is the most reasonable alternative.

SAMMANFATTNING (ABSTRACT IN SWEDISH)

En snabbt växande befolkningsökning samt urbanisering i utvecklingsländer såsom Nepal utgör ett hot för miljön. Urbaniseringen resulterar i en ökad mängd avfall och utvecklingen leder till nya levnadsmönster och – standard samt ändrade attityder vilket i sin tur ändrar avfallskompositionen. När nya industrier etableras förändras avfallssammansättningen till att innehålla mer och mer farligt avfall. Med utvecklingen uppstår problemen med avfall och situationen i Kathmandu är för tillfället akut. Miljöproblemen orsakade av otillräcklig avfallshantering i de växande städerna är en av de viktigaste miljöfrågorna för Nepals ledning.

Som examensarbete på Miljöingenjörsprogrammet, Högskolan i Kalmar finansierades denna studie genom två Minor Field Studies – stipendier från Sida. Studien utfördes parallellt och i nära samarbete med Sida projektet "Characterisation of pollutants from city dump/landfill in Kathmandu valley, Nepal, and preliminary studies on technical measures for their reduction" som påbörjades under 2003 i Kathmandu, Nepal och som leds av forskar vid institutionen för teknik, Högskolan i Kalmar.

Huvudsyftet med studien var att skapa en överblick över problemen inom avfallshanteringen i Kathmandu och identifiera frågor för vidare forskning. Arbetet fokuserades på den avslutade dumpningsplatsen Gokarna och den nuvarande dumpningsplatsen for avfall vid Balkhu, längs floden Bagmati.

För att undersöka den nuvarande situationen i Kathmandu gjordes intervjuer med personer involverade i avfallshanteringen i Kathmandu såväl fältstudier och besök vid Gokarna och vid den pågående dumpningsplatsen längs Bagmati. Resultatet av studien visade att ett samarbete som idag inte existerar mellan kommunen, statliga institutioner och den privata sektorn är nödvändigt för att möjliggöra förbättringar av avfallshanteringen. Även införda miljölagar och föreskrifter med påföljder som verkställs är nödvändigt. Det tydliggjordes att utbildning av allmänheten i miljöfrågor som avfallshantering är viktigt för att öka miljömedvetenheten och kunna arbeta för att förbättra situationen i Kathmandu.

För att åskådliggöra vilket hot dumpningsplatserna utgjorde mot omgivningen undersöktes vattenkvaliteten och avfallets sammansättning. Vattenkvalitetsanalyserna på vattenprover tagna i Bagmati uppströms och nedströms dumpningen vid Balkhu visade att vattnet är mycket förorenat men vidare undersökningar krävs för att se till vilken grad dumpningen bidrar till föroreningen. Litteraturstudier klargjorde att föroreningen i Bagmati har ökat under senare år.

En handplockningsanalys som utfördes på ett ton avfall på väg att dumpas vid Balkhu visade att den organiska delen var så hög som 67 %. Riktig avfallssortering i kombination med en kompostanläggning i Kathmandu skulle till stor del reducera volymen av avfall som behöver deponeras. Resultat från laboratoriestudierna visade att avfallet innehåller metaller och tungmetaller som slutligen kommer att läcka ut från dumpningsplatsen till omgivningen. Eftersom dumpningsplatsen inte har någon fundamental miljöskyddande struktur bedöms dumpningen vid Balkhu utgöra ett allvarligt miljöhot som inte kan fortskrida.

En modell, utvecklad av Växjö kommun, användes som en checklista och strukturell modell vid inventering och riskbedömning av den avslutade dumpningsplatsen Gokarna i Kathmandu för att undersöka möjligheterna att använda modellen i framtida miljöinventeringar och riskbedömningar av gamla dumpningsplatser i utvecklingsländer. Modellen visade sig vara fördelaktig att använda i utvecklingsländer eftersom det så kallade osäkerhetstalet möjliggör en inventering och riskbedömning trots brist på expertis, information, laboratoriefaciliteter etc. i landet. Sättet modellen är utformad på för att användas med ett minimum av resurser gör den intressant att använda i utvecklingsländer såsom Nepal. Eftersom modellen undersöker vilken dumpningsplats som orsakar störst miljöpåverkan ger den möjlighet att använda tillgängliga resurser där de behövs mest. Intervjuer och fältbesök visade sig efter erfarenhet vara de mest givande metoderna för att samla informativ fakta till undersökningen.

Resultat från en vattenkvalitetsundersökning, fältbesök och intervjuer användes för att med hjälp av riskbedömningsmodellen från Växjö slutligen klassificera Gokarna till riskklass 2 (B) d.v.s. vidare studier krävs för att undersöka om platsen utgör en konkret miljökonflikt. Genom att undersöka olika lösningar för den avstängda dumpningsplatsen Gokarna framkom att ett riktigt avslutande, med eventuell täckning och efterbehandling, är det rimligaste alternativet.

ACKNOWLEDGEMENT

We would like to thank Prof. William Hogland who as supervisor been very supportive and helpful during all stages of our research.

Many thanks are also directed to Dinesh Manandhar, Development Network (P) Ltd, who has been our local supervisor in Kathmandu, Nepal. Our work in Kathmandu would not have been possible to carry out without his guidance and encouragement. We want to thank the staff at Development Network (P) Ltd who always were helpful and made us feel welcome.

To the master students Sital Kafley and Suresh Mahaju in Nepal who have been co-operating with us throughout this project we are truly thankful. They have been indispensable during sampling, field visits and other practical work. As our friends they have been our guides trough Nepalese life and culture.

For interesting discussions, guidance and making the waste separation at Teku transfer station possible we would like to thank the staff at KMC, especially Rajesh Manandhar, Sanchaya Prajuli, Rabin Shresta, Mr Maheswor Bahadur and Shriju Pradhan Tuladhar.

Thank to Ashok Shahi, Surya Man Shakya and Murali Ranjitkar at SWM&RMC, Basudev Kharel Department of Mines and Geology and Ashok Tuladhar who has during interviews been very helpful with necessary information difficult to find in written form.

The staff at Zest Laboratories (Pvt.) Ltd and K.B. Shahi at NESS (P) Ltd is also acknowledged.

Also we would like to thank Dr Lennart Mårtensson, University of Kristianstad and Prof. Lennart Mathiasson, University of Lund who have as a part of the Sida project supported us with the analytical part of the project. We are deeply thankful to Britt-Marie Svensson, Lars Thörneby, Diauddin Nammari and Pille Kängsepp who all helped us with preparation and analyses carried out in Kristianstad

We also want to thank our beloved Andreas and Hampus who both have been incredible understanding and supportive during our stay in Nepal.

LIST OF CONTENT

1 INTRODUCTION

1.1 Background

There are urgent problems with the solid waste management in Kathmandu. To investigate and improve the situation the project named “Characterisation of pollutants from city dump/landfill in Kathmandu valley, Nepal, and preliminary studies on technical measures for their reduction” started up in Nepal during 2003.

The main objectives are to

- characterise leachate from landfills with emphasis on heavy metals and organic persistent pollutants
- compare the composition of the leachate from landfills in Nepal with the situation in Sweden and the Baltic Countries
- investigate the efficiency of different geofilters on-site in Nepal with respect to pollutant reduction in leachate
- use the information obtained from experiments and workshop discussions for building up competence in Sweden about waste management in Nepal
- contribute with expertise on leachate as help for improving waste management in Nepal
- create, together with information from other leachates investigated by us, a basis for standardization of evaluation methodology

The project is financed by the Swedish International Development Cooperation Agency, Sida, which is a governmental organisation. It will be carried out as a co-operation between the departments of Technology at the University of Kalmar, Kalmar, Sweden, the University of Kristianstad, Kristianstad, Sweden, and the University of Lund, Lund, Sweden during two years. The project is co-ordinated and supervised by the three senior reseachers in the LAQUA-group; Prof. William Hogland, University of Kalmar, Prof. Lennart Mathiasson, university of Lund and Dr. Lennart Mårtensson, University of Kristianstad. The three universities provide the interdisciplinary knowledge which is needed to solve the complex environmental problems created by insufficient waste management. The department of Technology, University of Kalmar has developed a great knowledge about water treatment technologies and waste management. The University of Kristianstad has expertise in air pollution and The University of Lund in analytical chemistry. The departments in Kathmandu involved in the project are the Central Department of Microbiology, Tribhuvan University, Environmental Public Health Organization and Development Network Pvt. Ltd.

As the final thesis of the Environmental Engineering Program, University of Kalmar, Sweden this report were written. The research is carried out partly in Kathmandu, Nepal and partly in Sweden and parallel and in close co-operation with the Sida project in Kathmandu, Nepal. The interdisciplinary character and knowledge of the Sida project has also been reflected in this study. The thesis also is a Minor Field Study, MFS, and financed with a scholarship given from Sida. To prepare for the study in a developing country a course "MFS-förberedelsekurs" was given by Sida in Gothenburg. The course gave an introduction for field studies in developing countries with classes in subjects as security, health and development.

Prof. William Hogland, University of Kalmar has acted as Swedish supervisor and Prof. Lennart Mathiasson, University of Lund and Dr. Lennart Mårtensson, University of Kristianstad have been responsible of the chemical analytical part of the project. Preparation of reprocessing and sampling were carried out in Kristianstad were final analyses of water, air and waste also have been made.

In Nepal field studies, interviews, sampling, reprocessing of samples, waste separation and discussions with people involved in solid waste management have been carried out. The local supervisor was Mr. Dinesh R. Manandhar, Development Network Pvt. Ltd, and research has been made together with students from Nepal also doing environmental studies. During the first week of the project field visits and discussions were carried out together with the Swedish professors to further shape the BSc thesis along with the Sida projects directions.

1.2 The Växjö risk assessment model

In 1988 Växjö municipality, Sweden started to develop a model to improve the methodology for inventory of old landfills to be able to identify their environmental risks. It has been developed and tested on old landfills in Växjö municipality, Sweden.

The objective with the Växjö project was to create an overview of old landfills in the municipality and their risks to the surroundings. Using the method an environmental protection act with measure programs, to eliminate the risk to the surroundings and local people's health, could be generated. Another aim with the project was to create a method that was as general that it could be used to make a risk assessment and environmentally protect older landfills also in other municipalities in Sweden. The systematic method is meant to be used with a minimum of resources and still generate effective environmental protective measures (Nilsson and Hult, 1990; Hogland, W., 1989).

The Växjö project was carried out in four phases; preparative studies, inventory, further investigation and measurement and control. During the first phase literature and field studies was carried out to be able to create a program suitable for the environmental inventory carried out during the second phase (Nilsson and Hult, 1990; Hogland, W., 1989).

The environmental impact caused by old landfill is complicated and complex. While the waste composition reflects the potential environmental risk of the landfill, the location of the landfill, with consideration of the surrounding ground, water, nature and houses, is determining to what level the landfill does affect the surrounding environment. To include all these factors the environmental inventory, the second stage of the project, was split into four projects dealing with different environmental aspects named waste/gas/leachate, geohydrology/groundwater, limnology/surface water and ecology/society (Nilsson and Hult, 1990; Hogland, W., 1989).

In the project part 1, waste/gas/leachate, the waste composition was investigated through interviews and inventories of industries, to estimate the potential environmental risk of the landfill. Also risks related to landfill gas and leachate was taken into consideration. A survey of the geo-hydrological conditions and the sensitivity of groundwater along with field studies was carried out to investigate how the surroundings of the landfill can be affected by leachate emissions during the project part 2, geohydrology/groundwater. During the project part considering Limnology/surface water affected surface recipients with respect to their sensitivity was investigated. The information was collected through field studies and analyses of physical parameters as pH, alkalinity, conductivity and colour. Mapping and evaluation of the sensitivity of the surface waters in the surroundings was also carried out. In the project part 4, Ecology/society, different land interests and how the landfills/dumps affect the landscape and nature was considered. Conflicts like damage on vegetation and landscape, littering or use of land etc. was therefore evaluated. Another fifth part of the inventory was supporting the other projects with information during the environmental inventory as an extra resource when needed (Nilsson and Hult, 1990; Hogland, W., 1989).

The information collected during the inventory was then treated and finally showed in a system of environmental and assessment factors to be able to handle all the data and compare different landfill/dumps in an environmental risk assessment. According to the result of the assessment all the landfills investigated were placed into either risk class 1, 2, 3 or 4 to know if further studies and where the most important and urgent environmental measures are needed (Nilsson and Hult, 1990; Hogland, W., 1989).

If further and deeper studies of certain landfills were assessed to be necessary, as in the case of landfills placed into risk class 1, 2 and 3, complementary investigations was carried out during the third phase of the project. During the last, fourth phase, further investigations, measurement and control was selected depending on the results of earlier studies and the environmental protection act formed during the third phase (Nilsson and Hult, 1990; Hogland, W., 1989).

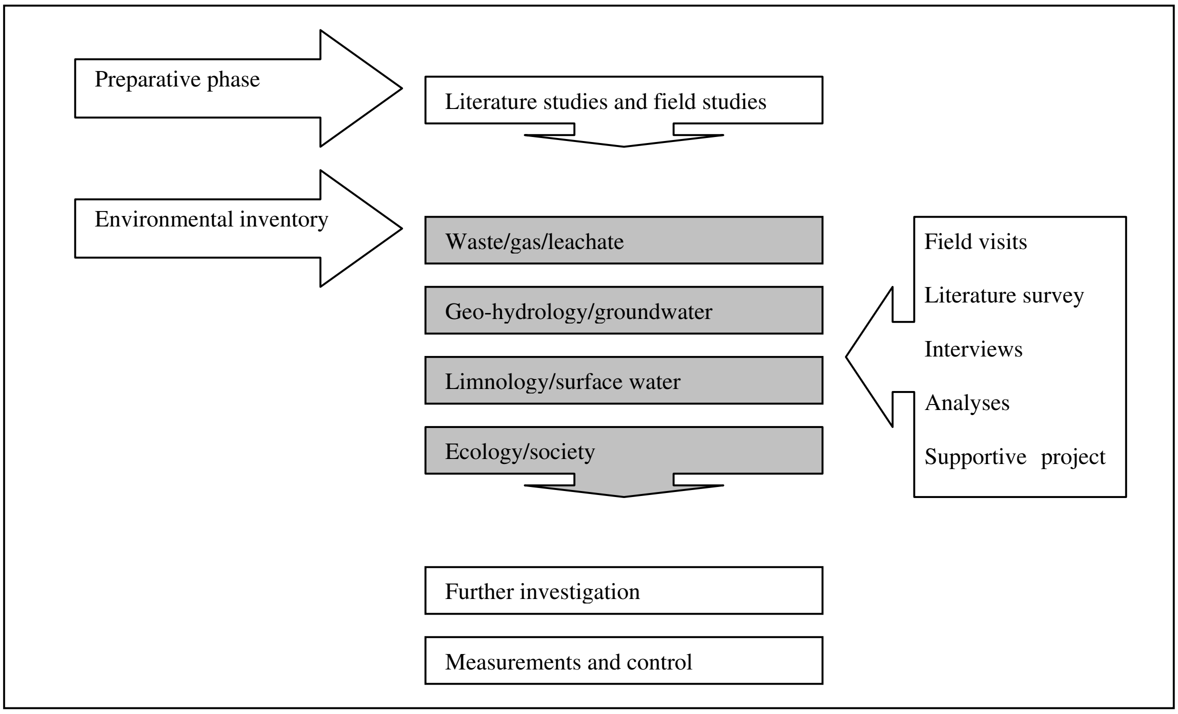

Figure 1.1 The diagram show the different parts and phases of the Växjö risk assessment model

The risk assessment used in Växjö municipality only consider environmental and health aspects and the assessment is made to detect the landfill/dump that holds the largest environmental risks and the most urgent need of improvements to protect the surroundings (Nilsson and Hult, 1990; Hogland, W., 1989).

In this project the model has been used as a checklist and structural model to investigate the possibilities to use a similar model for environmental inventories and risk assessment of old landfills in developing countries like Nepal.

1.3 History of the solid waste management in Kathmandu

1.3.1 Background

Back in time organic waste constituted the major part of the produced waste and the people felt responsible for their waste. Almost all waste was composted in household composts, ”saagas”, and the rest was reused and recycled (Karki, 2001).

The problems related to solid waste first occurred in Kathmandu when the population and the consumption increased in the Valley and people's attitudes were changed. No proper waste management was available the waste was simply dumped along Bagmati River. To solve the problem with the increasing amount of waste the first international aid was consulted in 1971 and in the 1980's Kathmandu received assistance from GTZ, Germany (Tuladhar B., 2000).

Further expansion of Kathmandu and Patan municipalities in recent years in combination with the establishments of new industrial and commercial units in the valley has resulted in an urgent environmental situation (SWM&RMC, 2003). Occurrences that have influenced the proceedings of the solid waste management in Kathamandu are shortly described in the Table 1.1 below and more exhaustive in following parts.

Table 1.1 Years of importance in the history of solid waste management in Kathmandu

1971	First international aid to solve problems due to solid waste was consulted
1976	The area for construction of Gokarna landfill were chosen
1981	GTZ Solid waste management project started *1981-83 Trial phase* *1983-90 Acting phase* *1990 Final phase*
1984	The construction of Gokarna landfill
1986	Gokarna opened for final disposal of solid waste The compost plant at Teku was introduced
1990	SWM&RMC started to manage the Gokarna landfill site Nepal got democracy
1992	The compost plant at Teku closed The first leachate pond at Gokarna was covered with waste
1993	Gokarna closed down for a couple of weeks
1994-95	Gokarna landfill site was closed Waste was dumped along the riverbanks of Bishnumati River
1995	Gokarna reopened KMC was given the responsebility for the site
1996	A new leachate pond was constructed at Gokarna landfill site
1999	The co-operation with JICA started
2000	The second leachate pond was covered with waste Gokarna final closure Waste started to be dumped along Bagmati River
2003	The riverbanks of Bagmati river is used for final disposal of solid waste

1.3.2 GTZ Solid Waste Management Project

GTZ Solid Waste Management Project was established in 1981 with technical and financial support from German Agency for Technical Cooperation (GTZ) under Federal Ministry for Economic Cooperation and Development (BMZ). In the early stage the project was under the Ministry of Work and Transport, on central level and cooperated with the municipality on local level (Tuladhar A.R., 2003).

The project can be divided into three phases; the trial phase, the acting phase and the final phase.

1.3.2.1 Phase I – Trial phase

In phase I, the trial phase of the project, ideas about how to implement a feasible waste management system in Kathmandu and Patan were discussed. An increasing amount of waste was collected every day with development of new brooms with long shaft and push-cars. During this phase, 1981 to 1983/84, the river banks along Bagmati River at Teku were used as dumping sites (Tuladhar A.R., 2003). Since the waste dumping along rivers was illegal the project started to plan for a landfill for final disposal of solid waste.

The problems with organization of the waste management in Kathmandu Valley lead to the establishment of Solid Waste Management and Resource Mobilization Centre (SWM&RMC) as a central body to solve the problems within the Valley (Tuladhar B., 2001).

1.3.2.2 Phase II – Acting phase

During phase II all steps in the waste management were taken into considerations; collection, transport, sorting, composting and landfilling.

In 1983 the preliminary design of the site was ready and the construction work for the new landfill in Nagdah Valley started. The final construction was completed 1985/86 and Gokarna landfill site was in operation late 1986 (Tuladhar A.R., 2003). As a part of the project a transfer station at Teku with a compost plant, a communal container collection system (Tuladhar B., 2000) and more technical and mechanical efficient vehicles for collection were developed (Tuladhar A.R., 2003).

Late in Phase 2 the project moved under the Ministry of Housing and Physical Planning and was renamed to Solid Waste Management Board (Tuladhar A.R., 2003).

1.3.2.3 Phase III – Final phase

In 1990 the GTZ Solid Waste Management Project decreased their financial support to financial and technical advice and assistance only (Shahi, 2003). The municipalities and the government took over the management, which resulted in confusion and an almost chaotic situation (Tuhladhar B., 2000).

In 1997 the team from GTZ Solid Waste Management Project came back to Kathmandu to investigate the site and the project resulted in the report "Hydrogeological & Geotechnical aspects of the final operation, closure & restoration of Gokarna landfill site, Kathmandu" (Oeltzschner and Kharel, 1997). Before the closure of Gokarna landfill site, other areas for dumping were tried out.

1.3.3 The history of Gokarna landfill site

1.3.3.1 Background

In 1976 after an assessment of 12 possible landfill sites, undertaken by Professor O. Tabasaran, Gokarna landfill site, located at the southern edge of the Gokarna Forest, was chosen. The area was seen as exemplary both aesthetically and environmentally for construction of a landfill (Oeltzschner and Kharel, 1997). Before opening several investigations on the geological, hydrogeological and geotechnical conditions of the area were carried out and closeness to the Tribhuvan International Airport was the only negative aspect considered when it opened for final disposal 9 November 1986 (Oeltzschner and Kharel, 1997). When the site was chosen 1976 its volume was estimated to be 10 million m^3 but further examination showed just a volume of 1.1 million m^3 (Oeltzschner and Kharel, 1997).

1.3.3.2 Construction

The construction started in 1984 and consisted of a small office building, a small guard house, a dozer garage, the foundation of the landfill, channeling of the surface water, a cross wall, a leachate pond and a boundary wall. Wishes and cravings also directed what to be constructed at and around the site. To make compromises with the surrounding settlement the project constructed a pond for the animals, a road approaching the Mulpani Village and a water supply system (Tuladhar A.R., 2003).

Gokarna landfill was ready for operation 1985 but before opening a bridge across Bagmati River had to be constructed and the landfill was set in operation in late 1986 (Tuladhar A.R., 2003).

1.3.3.2.1 Foundation

In the lowest, west, part of the valley, and on top of a channeling pipe, 15 cm of clay was placed with 30-50 cm of gravel on top of as a foundation. The foundation was constructed to reduce the possibility of accumulation of leachate inside the dumped waste and to lead the water to the leachate pond (Tuladhar A.R., 2003).

1.3.3.2.2 Leachate pond

A leachate pond (1x1.25 meter) was constructed with a foundation of 45 cm Black soil with 25 cm of gravel on top (Tuladhar A.R., 2003). The inflow came from seepage from the bottom of Gokarna through a stone wall without any pipe. The only outflow from the pond was the pipe for leachate overflow that led to a manhole. The leachate was meant to be recycled: spread on the landfill, and that no leachate should leave the landfill site. During the monsoon the leachate pond was overflowed and some of the water was led to the manhole where the leachate was diluted with the surface run off that came through the channeling. The assumption was that the leachate could be filtrated naturally through the 600-800 meters of soil to the Bagmati River (Tuladhar A.R., 2003).

1.3.3.2.3 Channelling pipe

To drain the rain water catched by the valley out of the dumping area a pipe with the diameter of 75 cm was placed in the bottom of valley separated from the waste. It was placed from the lower part of the site and was extended upwards as the site expanded (Tuladhar A.R., 2003).

1.3.3.2.4 Cross wall

The cross-wall made of stone, at the lowest level (west) of the dumping area, was constructed to separate the waste from the leachate pond. Leachate was meant to percolate trough the wall to the leachate pond. The channeling through the landfill runs trough the cross wall to the manhole (Tuladhar A.R., 2003).

1.3.3.2.5 Boundary wall

The boundary wall was constructed at the west border of the landfill site. It was built to protect the leachate pond by creating barriers to the animal and children who enter the valley from the close villages. The construction was also to enable the overflow of the leachate pond into the stream in rainy seasons and protect the dumping site from the west aesthetically and environmentally (Tuladhar A.R., 2003).

1.3.3.2.6 Animal pond

The pond was located on the south east side of the dumping area. It was situated within the religious holy place inside the dumping site where the dumping of waste was first prohibited. This pond was used by the cattle and other animals from surrounding villages for drinking purposes and swimming (Tuladhar A.R., 2003).

1.3.3.3 Solid waste management between 1986 – 1990

During the Solid Waste Management Project when SWM&RMC still got assistance from GTZ the landfill was managed properly (Tuladhar B., 2000). A 50 – 60 % compaction (Tuladhar A.R., 2003) was made on all incoming waste and was then deposited in 60 cm thick layers after being compacted (Oeltzschner and Kharel, 1997). To avoid littering and bad smell the waste was covered every day with 15-30 cm thick (Tuladhar A.R., 2003) layers of soil, taken from nearby slopes of the valley (Oeltzschner and Kharel, 1997). During the operation 300 tons or 600 m^3 of waste from Kathmandu and Lalitpur per day came to Gokarna landfill (Tuladhar B., 2000).

A consultant was hired to monitor the water quality around the landfill. When the project was completed the Germans gave equipment to the municipality to continue the monitoring of waste water and surface water. Samples were taken from the monitoring wells and given to lab for analysis (Shahi, 2003).

1.3.3.4 Solid waste management between 1990 – 2000

In 1990 when GTZ gave SWM&RMC the responsibility to manage Gokarna landfill problems started to appear. The municipality, KMC, then later got the responsibility in 1995 but did not have the capacity to take care of Gokarna landfill site (Manandhar, 2003).

Because of negligence in maintenance the management had to face strong criticism from the public often threatening to close the site (Oeltzschner and Kharel, 1997). Efforts in maintenance of the site was only done when crisis where created, which resulted in very costly solutions that did not prevent future negative environmental consequences (Oeltzschner and Kharel, 1997).

Nepal got democracy in 1990 and the political upheaval in early 1990 further aggravated the maintenance of the landfill site (Oeltzschner and Kharel, 1997). Since the people got their democratic rights and thereby also the right to complain, more complaints about the Gokarna landfill and how it was maintained came (Manandhar, 2003; Tuladhar A.R., 2003). Around 1991/1993 the serious problems at Gokarna started as a result of following incidents.
The compost plant at Teku, with a capacity of 3 tonnes, closed in 1992 and the amount of waste that came to Gokarna increased and the one dozer, used for compaction, was not sufficient (Shahi, 2003). There were no road or other infrastructure at the site and the vehicles drove and dumped waste near the leachate pond. Since the compaction was inadequate a big landfill slide in 1992 covered the entire leachate pond with waste (Shahi, 2003; Oeltzschner and Kharel, 1997).

The waste was not covered properly which resulted in a lot of litter at the site and in the surroundings. Insufficient management and preparation of the site in combination with the extreme monsoon 1993 resulted in local protests and the first closure of the site for a couple of weeks (Oeltzschner and Kharel, 1997).

During 1994-1995 the site was closed again, this time for about one and a half years due to protests from local people. While the landfill site was not in operation the waste was dumped along the Bishnumati River between Shobhabhagwati and Balaju (Tuladhar B., 2000; Tuladhar A.R., 2003). After negotiation between the ministry, that promised to manage the site in a environmentally and aesthetically proper way, and the public, the landfill could reopen 1995 (Tuladhar A.R., 2003).

1.3.3.4.1 Channelling pipe

The channelling pipe was extended upward with the shape as a Y with two entrances uphill. After 150-175 meters of extension of the pipe pointing to the south it was closed. After the closure of the pipe a suspected liquid started to come out of the channeling and it may have been inadequately constructed. The other pipe was extended all the way up to the end of the landfill (Tuladhar B., 2000). Even though the extension of the pipe was maintained properly a crisis situation in 1995 resulted in an over load of the channeling pipe when the municipality put more waste on top of the lower part of the site (Tuladhar A.R., 2003; Shahi, 2003). Since there was no flow for several years the pipe assumes to be broken or clogged (Tuladhar B., 2000).

1.3.3.4.2 New leachate pond

Since suspected liquid started to come out from the channeling pipe local people protested and a new collection pond had to be constructed in 1996-97 (Shahi, 2003). From the new leachate pond a pipe was constructed that led overflow from the pond to Khahare Khola which ends up in Bagmati River (Shahi, 2003). The collection pond was badly constructed, not functional and was finally covered with waste in June 2000 when no other space was available (Tuladhar B., 2000).

1.3.3.4.3 Foundation

No foundation was laid and the waste was put directly on the ground (Shahi, 2003).

1.3.3.4.4 Measure of gas and liquid

There where no measures of gas or liquid pollution or their environmental impact to the surrounding (Oeltzschner and Kharel, 1997).

1.3.3.5 <u>Closure</u>

The landfill was finally closed the end of June 2000 since the site was considered full. No alternative landfill site to Gokarna landfill was available and the government did not provide the 10 ha of land that KMC had requested for a compost plant. KMC was again forced to start the dumping along Bagmati River (Tuladhar B., 2000).

1.4 Solid waste management in Kathmandu

1.4.1 Solid Waste Management and Resource Mobilization Centre (SWM&RMC)

In 1990, when GTZ Solid Waste Management Project finished their financial support, the municipalities started to work with the waste management. The municipalities finally got the full responsibility in 1995 when SWM&RMC closed all their activities with waste management to only support them financially and technically (Shahi, 2003).

Today the SWM&RMC works to support the five municipalities in the Kathmandu Valley; Kathmandu Metropolitan City (KMC), Lalitpur Municipality, Bhaktapur Municipality, Madhyapur Thimi Municipality and Kirtipur Municipality in the field of solid waste management. To assist the municipalities in issues like development and infrastructure, and support them technically and financially, 18 people work on contract basis at SWM&RMC (Shahi, 2003). Since the municipalities and the SWM&RMC work individually without any cooperation, the municipalities take their own decisions and ask the centre for support when needed (Shakya, 2003).

Additionally SWM&RMC work with developing guidelines for waste management. “Solid Waste Management & Resource Mobilization Centre Act” that was approved by the government in 1987, is the key legislation for Solid Waste Management in Nepal. Recently “Policy and Legislation for Solid Waste Management in Nepal” was precented during Refresher Seminar in Solid Waste Management and Engineering (Shakya, 2003).

1.4.2 Kathmandu Metropolitan City (KMC)

Within the municipality of Kathmandu, Kathmandu Metropolitan City, four sections are working parallel with environmental tasks; Environmental Department, Solid Waste Management Section, Maintenance Section and Urban Environment Section (KMC, 2003). The Solid Waste Management Section of KMC has the responsibility for the entire solid waste management in Kathmandu city i.e. organization, street sweeping, collection, transports, transfer station and final disposal. KMC employs 1050 sweepers, 30 mechanics, 117 drivers, 2 officers, 9 engineers and about 50 administration staff (Manandhar, 2003).

The administrative part of the section works with tasks as community awareness programs, school children programs, training programs etc. Since 1997 the two major tasks have been to promote private sector participation in the waste management and to develop a compost plant (Manandhar, 2003). The main goal is to establish an integrated solid waste management system, which is efficient, cost effective and with maximum involvement of local communities as well as the private sectors (KMC, 2003).

In the past KMC has improved the collection system, the community participation and pressured the government to establish a central compost plant (KMC, 2003). When all the waste management responsibilities were handed over to the municipalities in the late 1990's KMC was struggling to provide adequate solid waste management services to a rapidly increasing population (KMC, 1999). Due to political conflicts and lack of resources KMC still usually have to act in a stage of crisis (Manandhar, 2003).

1.4.3 NGOs and private companies working in the field of Waste Management in Kathmandu

KMC co-operates with both NGOs and private companies (see APPENDIX 3). NGOs have been involved in the waste management of Kathmandu since five years back and today about three cooperate with KMC, involved with recycling, waste collection and composting (Tuladhar S.P., 2003). About 13 private companies work in the field of solid waste management, manly with transporting waste (Manandhar, 2003; KMC, 2003).

1.4.3.1 Japanese International Cooperation Agency (JICA)

In 1999 the government of Nepal requested the government of Japan to carry out a study of the waste management in the Kathmandu Valley. The objective of the study was to formulate a master plan of solid waste management for the Valley and then the most feasible project should be chosen and the most urgent needed improvements should be identified and implemented first. Due to economical reasons and the environmental distress an action plan for implementation of a pilot project for each of the five municipalities was formulated instead. The agreement is until 2015 and JICA will additionally assist on studies of the suggested new landfill site in Okharpauwa (Shahi, 2003).

1.4.4 New landfill site

A new landfill site, Bancharedanda landfill site, on suggestion by the Ministry (Manandhar, 2003), is under construction and located in Okharpauwa outside Kathmandu Valley. Close to the Bancharedanda site Sisdol is located where a temporary landfill is constructed but still not in use. The site in Sisdol is meant to be used for 2-3 years until the construction of Okharpauwa site is complete (Manandhar, 2003). The area is also planned to be used for the compost plant managed by Luna Nepal Chemicals & Fertilizers (P) Ltd. According to SWM&RMC's plans the site in Sisdol will start to operate 2004 (Shakya, 2003). The distance to Sisdol from the industrial area Balaju is 16.6 km and from Teku transfer station 21.6 km (Shahi, 2003). The approach road has been improved but is still very narrow and in bad condition though further construction work is said to be carried out (Tuladhar A.R., 2003).

1.4.5 Waste generation and waste characteristics

During the last years the total waste generation has increased in Kathmandu with the same rate as the increase of population and is today 250 tonnes per day (see APPENDIX 4). After increasing the amount of waste that is produced per person and day in the valley to 0.225 kg the amount has remained constant during the last years. All waste is not included in the calculations since some of it is just dumped by the river or in the backyard without getting collected. In Nepal a part of the recoverable materials get sorted out in the households and in the streets before it is classified as waste. The households take care of things that can be reused and some organic waste, which has always been the majority fraction, become animal feed or composted. The waste characteristics depend on factors as standard of living, income, level of sorting, industries etc.

Solid hazardous industrial waste is produced in limited amounts in Kathmandu; most hazardous industrial waste is liquid. Before there was a battery factory in Balaju that produced hazardous waste as lead, cadmium and zinc but it is now shut down (Manandhar, 2003).

1.4.6 Collection

Most of the people dispose their domestic waste either in the streets or in public waste containers (KMC, 1999). The municipal sweepers clean the streets and collect the waste, usually by handcarts, before it is loaded on either tractors or trucks (KMC, 1999). In the streets plastic, paper and metals are collected and when the waste reach the transfer station and the dumping site scavengers sort out another percentage of the paper, plastic and metals (Manandhar, 2003).

In Kathmandu the waste is collected by the different wards and taken to either Teku Transfer Station (40 % of all waste) (Manandhar, 2003), where it is unloaded on to a concrete platform, or directly to the dumping site at Balkhu. At the transfer station the waste is loaded on to bigger vehicles before it is taken to the dumping site (KMC, 1999).

Private and municipal sectors collect waste from the streets, from door-to-door or by a container system. Currently 90% of the total generated waste in Kathmandu is collected using following methods (Manandhar, 2003);

Roadside collection	451 m^3/day (50 %)
Door-to-door collection	259 m^3/day (29 %)
Container collection	185 m^3/day (21 %)
Total	**895 m^3/day**

(KMC)

Until 1998, 50 public containers and 67 containers were offered for use for enterprises who wanted the service (Shahi, 2003). Now there are 30 public containers, 4-6 m^3 and 3-4 bigger containers, 20m^3, (Manandhar, 2003) that are placed at certain hospitals, hotels, governmental offices and embassies (Shahi, 2003).

1.4.7 Incineration

Incineration of waste is carried out in limited extent in Kathmandu Valley with one incineration plant in operation at Patan Hospital. Small incineration plants, with a capacity of 400 kg/day, have been tried out on medical waste, during the time when there was not any mayor in Kathmandu. People protested loudly since they did not trust the plants and did not want them close to their houses. There are still oppositions for incineration of medical waste since no one knows who is responsible for the medical waste and people protest (Manandhar, 2003).

Due to the fact that no one knows who is responsible for the medical waste, no one takes the responsibility of handling the waste properly. Today the 2 tonnes medical waste that is generated per day is dumped along with the municipal waste at Balkhu along Bagmati River. The confusion is that the big hospitals are under the responsibility of the Ministry of Health, teaching hospitals are under Ministry of Education and nursing hospitals are under the Ministry of Industry (Manandhar, 2003).

1.4.8 Composting

In 1986 GTZ Solid Waste Management Project introduced a semi-mechanized screening plant with windrows at Teku transfer station. The plant produced maximum one tonnes compost per day but was difficult to manage manually (Tuladhar A.R., 2003). The plant was maintained until 1991 when local people at Teku started oppose the compost plant and the screening machine did not work properly (Manandhar, 2003).

The fraction of organic waste is high in Kathmandu and there have been plans to start a new compost plant since the one constructed at Teku shut down. On 5 September 2003 SWM&RMC and KMC signed with the private company, Luna Nepal Chemicals & Fertilizers (P) Ltd to run a compost plant at Sisdol (Manandhar, 2003; Shahi, 2003). The plant shall be established using SEGHERS/SLIAS Technology/ Process or any technology that is equally or more advanced than SEGHERS/SLIAS (SWM&RMC, KMC and LNC&F (P) Ltd., 2003). The german technology that Luna Nepal Chemicals & Fertilizers (P) Ltd will use is a closed system where the final product will be a compost fertilizer (Shahi, 2003).

The plant will have a capacity of handling 200 – 300 tonnes of waste per day with a possibility of extension. SWM&RMC will provide the power and water and other necessary infrastructure and the company will pay for the consumption (SWM&RMC, KMC and LNC&F (P) Ltd., 2003).

KMC has given a new suggestion of a site for composting. The area is located in Chobar not far from Teku Transfers station and has been used by a cement factory (Rajesh, 2003).

The Community Mobilization Unit (CMU) at the Environmental Department of KMC organizes programs with emphasis on solid waste management with focus on education. They have also designed and produced a compost bin for households. The bins that have been on the market for one year have sold in 300 units. NGOs in other municipalities have copied the bin (Tuladhar S.P., 2003). In different areas of Kathmandu NGOs and CBOs also have promoted Vermi compost bins for households.

A 3000 liter community compost bin, used by 100 households, in Ratupul, Kathmandu Valley, started by Sagaramatha Environmental Development Center has solved the problem with solid waste in the area (Tuladhar S.P., 2003).

1.4.9 Recycling and scavenging

In Kathmandu there is no material recovery or recycling industries though some demolition waste is sorted out and reused in the private sector. A great part of materials is sorted out in the households, on the streets, in the industry and commercial contexts.

People who earn their living by sorting waste in the streets, at the transfer station and dumping site are called scavengers. The materials that are sorted out by the scavengers; plastics, paper, glass and metals (KMC, 1999), are sold to private companies that sell it, mostly to India, were it is used to make new second grade materials. There is a tax for bringing out materials from the municipality limiting the recycling initiatives within the Valley (Manandhar, 2003).

Since there is no provision of separation, collection, handling or disposal of hazardous waste, all kinds of waste mix up and sorted through by the scavengers. Due to poor economical condition and awareness the scavengers are exposed to hazardous materials without any protection (Manandhar, 2003). Protective clothes and all types of management are absent and the working condition is poor (Manandhar, 2003) (see APPENDIX 1, Picture 1 and Picture 2).

2 OBJECTIVE

The main objective is to make a survey of the conflicts of the solid waste management in Kathmandu and identify issues for further investigations. The work is focused on Gokarna landfill site and the dumping of solid waste along Bagmati River. Measures of improvement will be suggested. The study will be carried out closely connected to the Sida project; “Characterisation of pollutants from city dump/ landfills in Kathmandu Valley, Nepal, and preliminary studies on technical measures for their reduction” carried out by the LAQUA group during 2003 and 2004.

The risk assessment of Gokarna landfill site will follow the structure of “the Växjö risk assessment model” to evaluate the model and suggest adjustments to make it more useful in developing countries, such as Nepal.

3 SCOPE

This BSc thesis is limited to environmental impact due to solid waste in Kathmandu municipality. Limited measurements and chemical analyses are made and only one sample is taken on every samplings spot why the significance of the result must carefully be considered.

Practical work with sampling and analyses is limited by time to ten weeks stay in Kathmandu, Nepal, one week of laboratory work in Kristianstad Sweden and some laboratory work in Kalmar and Lund, Sweden.

Samples for PCB are collected, reprocessed and analysed but the interpretation will not be carried out during this project but will be presented in the Sida main project.

An air quality investigation is carried out but the results are neither evaluated nor further discussed.

The risk assessment of Gokarna is limited by the instruction given by the Växjö risk assessment model and to the limited measurements carried out on Gokarna landfill site. After classification no environmental protection act will be formed and no further investigation or measurements will be carried out. The result will only be discussed and used to investigate the possibility to use the risk assessment model developed and used in Växjö municipality, Sweden, in Nepal and other developing countries.

4 METHOD

4.1 Field studies and visits

To gain information for the study, field trips were carried out on the landfill site, the transfer station and the present dumping site where photos were taken and observations were noted down. Useful information and contacts for further interviews have also been gathered by visiting universities, companies and governmental and municipal offices in Kathmandu. Some of the visits were in company with the professors from Sweden and/or the local supervisor. During "Seminar on Waste Management in Developing Countries" arranged by Development Network Pvt. Ltd. and held in October 2003, Kathmandu, useful information was collected.

4.2 Literature survey

To prepare for the field study articles, journals, papers and books related to the issue were collected at the Internet, library and university. In Kathmandu literature such as reports and old measure data was gathered from companies, organisations and the municipality and governmental institutions.

4.3 Interviews

After literature study, visits and field trips, all remaining questions were compiled and interview protocols were formed. Persons, possibly being in possession of interesting and useful information, such as the staff at the municipality and people in relation to the landfill site, were interviewed. People living close to the old landfill site were interviewed in there opinions and memories from the time when the site was in operation. After gathering the information it was analyzed and compared with reports and other literature to draw conclusions. Usually a second interview had to be held as a complement.

4.4 Water quality investigation

4.4.1 Sampling

4.4.1.1 Sampling sites

Water samples were collected from totally 15 spots; 11 around Gokarna landfill site and 4 in Bagmati River (see APPENDIX 5 and APPENDIX 2, Map 1):

- 3 monitoring wells west from Gokarna landfill site
- 7 samples from roar pumps or dug wells used for drinking water around Gokarna landfill site
- The channelling pipe through Gokarna landfill site
- Upstream and downstream the dumping site at Balkhu along Bagmati River

The deionised water from the laboratory where the bottles were washed and the reprocessing was carried out in Zest laboratories, Kathmandu, Nepal, was analyzed together with the other samples. The sample is referred to as "Blank" and show if there are any contamination from the deionised water.

4.4.1.2 Sampling bottles

For sampling different types of bottles were used and which bottle used depended on what parameter to be analyzed. All bottles were labeled systematically and brought to lab in a bucket.

Samples to be analyzed for metals were poured into 25 ml plastic bottles, washed with acid. The sample were also preserved with acid and left in room temperature before sent to Sweden.

For samples to be analyzed with reference to phenols, salts, TOC and DOC 100 ml plastic bottles, washed in methanol and deionized water, were used. The samples were preserved in freezer in Nepal before sent to Sweden packed in a box with ice-packs.

500 ml glass bottles, washed in methanol and deionized water, were used for samples to be analyzed with reference to PCB and SVOCs. The sample where either reprocessed immediately or preserved in freezer until reprocessing.

4.4.1.3 The sampling procedure

When samples were taken from monitoring wells downstream Gokarna landfill a bamboo stick and a rope was used. A half liter bottle was attached with the rope at one end of the bamboo stick before slowly lowering the arrangement down into the well. When beneath water level the bottle where filled up before it was hoist up and the water was distributed among the different bottles (see APPENDIX 1, Picture 3).

When samples were taken from roar pumps around Gokarna the water was pumped straight into a half liter bottle before distributed. Before sampling some water were pumped through the system in order to avoid still standing water in the samples (see APPENDIX 1, Picture 4).

The samples taken from electrical pumps upstream Gokarna were taken straight from the tap into a half liter bottle before distributed into different bottles. From the channeling pipe through Gokarna the sample was taken straight into the bottle (see APPENDIX 1, Picture 5). The samples taken in Bagmati River upstream and downstream Balkhu dumping site were taken in half litre bottles straight from the river before distributed.

While sampling, pH and conductivity were measured on site. All information was kept in a field-logbook.

4.4.2 Reprocessing

The samples taken for analysis of PCB and SVOCs were reprocessed in Nepal using the SPE; Empore disc and filtration according to Westbom to minimize the volume to be sent to Sweden for analysis.

Using a vacuum pump 0.5 liter of the sample was filtrated through a filter package containing 1 GF/D (2.7μm), 1 GF/C (1.2μm), 1 GF/F (0.7μm) and in the bottom 1 SPE-disc. To dry the SPE-disc and the filters the sample was filtrated in vacuum until all visible water was gone. (see APPENDIX 1, Picture 6). The filters that belonged together and the SPE-disc were folded and made two packages in Aluminium foil. All the packages were put in freezing bags and stored in refrigerator. The packages were sent with a carrier to Sweden together with the other samples for elution and analysis.

4.4.3 Chemical analyses

4.4.3.1 Salts

Salts were analyzed with Ion chromatography according to SWEDISH STANDARD SS-EN ISO 10304-2 (SVENSK STANDARD SS-EN ISO 10304-2, 1995).

4.4.3.2 Metals

The metals were analyzed with ICP-MS in Lund, Sweden.

4.4.3.3 Phenols

Six phenols were analyzed;

- Phenol
- p-Creosol
- o-Creosol
- 4-Chlorophenol
- 2,4-Dimethylphenol
- 4-Chloro-3-methylphenol

First the samples were acidized to pH <2 and then analyzed with HPLC in Kristianstad, Sweden.

4.4.3.4 PCB and SVOCs

To get a solvent extract, containing the interesting substances, SPE-discs and filters were eluated with a solvent. 20 ml isooctane was filtrated through the filters and the SPE-discs using a vacuum pump. The eluate was then evaporated to a volume of 1 ml, weighted and poured into small vessels. The PCB and SVOCs were analyzed using GC-MS in Kristianstad, Sweden.

4.4.3.5 General scan

A general scan for substances was carried out with GC-MC in Kristianstad, Sweden on four chosen samples;
Sample 4: Roar pump by monitoring well 2
Sample 9: Channeling pipe through landfill
Sample 12: In Bagmati River downstream dumping site
Sample 15: In Bagmati River upstream dumping site

To automatically find the set of target compounds in data file from the GC-MC Automated Mass Spectral Deconvolution & Identification System (AMDIS) was used. The program first deconvoltes the GC/MS data file to find all of the separate components. Each of these components is then compared against a library of target compounds. The match factor between the target spectrum and the deconvoluted component spectrum is then reported if it is above a user set value (Mallard and Reed, 1997).

4.4.3.6 TOC and DOC

TOC and DOC were analyzed with IR in Lund, Sweden, on four chosen samples;
Sample 4: Roar pump by monitoring well 2
Sample 9: Channeling pipe through landfill
Sample 12: In Bagmati River downstream dumping site
Sample 15: In Bagmati River upstream dumping site

4.4.3.7 Total phosphorous

Total phosphorous was analyzed with DrLange in Kalmar, Sweden, using LCK 349 with the detection limit of 0.05-1.50 mg/l PO_4-P .

4.4.3.8 Ammonia

Analysis of ammonia was carried out with Dr Lange in Kristianstad, Sweden. LCK304 were used with a detection limit of 0.015 – 2.0 mg/l NH_4-N.

4.5 Two stage batch test

4.5.1 Sampling

To sample for the analysis two holes were excavated in Gokarna landfill site. One hole was excavated 4.5 meter deep in the old part (A) of the landfill and another one 2.8 meter deep in the lower, newer part (B) of the landfill.

Samples were taken from the two piles by the two excavated holes. They were taken by hand, about three decimeters deep into the piles, from five randomly chosen spots in each pile.

Until the samples were dried in an oven for three days and nights in 95°C they were kept in airtight plastic bags in room temperature. Additional samples were taken in the same way as the others on a different occasion and were dried for five days and nights in 95°C. Directly after cooling down, both sets of samples were separated by hand and the soil fractions were kept in airtight boxes until they were sent to Sweden for analysis.

4.5.2 Two stage batch test methodology

The two stage batch test including calculations of the TS in the soil, shaking and filtrations were carried out according to EUROPEAN STANDARD EN 12457-3 (EUROPEAN STANDARD EN 12457-3, 2002).

The shaking was carried out on soil from both hole A and hole B and with a liquid/solid ratio of 2 and 10 which resulted in four samples of "artificial leachate";

HALS2: Hole A, L/S 2
HBLS2: Hole B, L/S 2
HALS10: Hole A, L/S 10
HBLS10: Hole B, L/S 10

4.5.3 Analyses

HALS2, HBLS2, HALS10 and HBLS10 were analyzed together with the other water samples and respecting the same parameters.

4.6 Handpicking analyses

4.6.1 Handpicking analysis of waste from Gokarna landfill

Handpicking analysis was carried out on old waste from Gokarna landfill site. The waste samples were collected from a three-meter deep hole that was excavated in the old part Gokarna landfill. From different parts of the pile with excavated material approximately 100 kg waste was collected in three big bags and stored outside the laboratory until the separation was carried out. Observations were made already during excavation and also certain materials could be observed.

While carrying out the separation the waste was spread on a plastic cover and sorted by hand into following fractions;

- Organic waste/ soil (everything unidentified because of degradation)
- Plastic (all types of plastics)
- Glass/ ceramics
- Textile
- Bricks (pieces that have been used as construction material)
- Leather
- Paper (often highly degraded)
- Wood (pieces that have been used as construction material, twigs where considered as organic waste)
- Metal (all types of metals)
- Rubber (inclusive foam rubber)

The different fractions were collected in plastic bags that were weighted in the end of the separation. To get the total weight, the weights of the different fractions were added together and then the percentage of each fraction was calculated.

To correct errors caused by dirt and moisture a representative sample of plastic bags was weighted before it was cleaned and dried. When clean and dry the plastic was weighted again and the result was used to correct the percentage of the different fractions of materials.

$$Weight\ 1 - Weight\ 2 = Weight\ 3$$

$$\frac{Weight\ 3}{Weight\ 1} = \%\,Moisture\ \ \&Soil$$

Weight 1: Bags with moisture and soil from the analysis
Weight 2: Dry and clean bags after cleaned and dried
Weight 3: Weight of moisture and soil

4.6.2 Handpicking analysis at Teku Transfer Station

A one-day-separation was carried at Teku Transfer Station. Seven scavengers were hired to take samples and sort the waste into chosen fractions (see APPENDIX 1, Picture 7). A “supervisor” was giving the instructions for the separation. The work was under observation to see that everything was carried out properly. To avoid soil mixing with the sample the ground under the waste was covered with a plastic sheet.

Waste samples were taken from different incoming trucks with waste collected from different ward in the municipality (see APPENDIX 2, Map 2 and APPENDIX 6). The samples were taken randomly in the trucks that were chosen randomly to get as representative samples as possible. The samples weight were continually checked to get minimum one ton waste for the analysis and for this purpose a 50 kg scale was used (see APPENDIX 1, Picture 8). The waste was separated into following fractions:

- Paper
- Plastics
- Textiles
- Rubber
- Leather
- Glass
- Metals
- Organic waste
- Wood (that has been used as construction material)
- Non-combustibles (bricks, concrete, stones etc.)
- Hazardous waste (batteries, oil, lubricants etc.)
- Hospital waste

Different fractions were weighted separately and notes were continuously taken (see APPENDIX 6). After separation the mass left on the plastic sheet, the fine fraction, was observed. The fine fraction was dried out by the sunlight and was considered small enough to be eliminated from the calculations. The percentage of each fraction was calculated by dividing the mass of one fraction with the total mass.

Waste samples from the rough fraction and the fine fraction were taken, packed in air tight boxes and brought to Nepal Environmental & Scientific Services (P) Ltd. (NESS (P) Ltd) where the energy value, ash residue, heavy metals in the ash and moisture content were analyzed (see APPENDIX 1, Picture 9).

4.7 Grain size analysis

4.7.1 Sampling

The samples used for the Grain size analysis were the same as were collected for the Two stage batch test (See 4.5.1 Sampling).

4.7.2 Grain size analysis

Before starting the analysis, the soil was sieved for soil passing through the 4.75 mm sieve and weighted. The sieves and the pan were cleaned with a brush and weighted with an accurancy of ± 0.1 g.

The soil was first sieved through 2 mm, 850 µm, 425 µm, 150 µm and 75 µm using a mechanical shaker for 10 minutes. Then each sieve and pan was weighted with an accurancy of ± 0.1 g with the soil retained on them. The sum of the retained soil mass was checked against the original mass of soil taken and after calculations the percentage of each diameter could be shown in a graph (Jain et al., 1984).

4.8 Air quality investigation at Teku Transfer Station

4.8.1 Sampling

Two samples of air quality at Teku Transfer Station were taken using SKC Passive Samplers. The passive samplers were placed on two scavengers who wore them for five hours during normal working conditions (see APPENDIX 1, Picture 10). As a reference one sampler was put up outside KMC's office a hundred meters from the scavengers working place, and another one outside a window of Moonstay Lodge located in Basantapur, in the city of Kathmandu. The samples were stored in refrigerator until they were sent with a carrier to Sweden together with the other samples.

4.8.2 Analysis

The eluate from the samples was analyzed with GC-MS in Kristianstad, Sweden. To automatically find the set of target compounds in data file from the GC-MC, Automated Mass Spectral Deconvolution & Identification System (AMDIS) was used (Mallard and Reed, 1997).

4.9 The Växjö risk assessment model applied on Gokarna landfill site

The environmental assessment in this project was made on one landfill, Gokarna landfill, instead of a comparison between several different landfills as during the Växjö project.

The information used for inventory and risk assessment of Gokarna was collected through laboratory studies as well as field studies and interviews. The structure followed "the Växjö risk assessment model" to evaluate the model and its usability in developing countries, such as Nepal.

Most attention has been given to the first project waste/gas/leachate and research about surface and volume, amount of visible waste/litter and waste composition has been made to map the amount and composition of waste in Gokarna landfill. Additionally the presence of gas and leachate was investigated and taken into consideration (Hogland et al., 1990; James and Niemczynowicz, 1992).

Further geo-hydrology, groundwater, limnology and surface water condition in the area and how the landfill has influenced the ecology and society have been investigated. The fifth part of the project that is meant to support the project with additional information needed has not been applied during this project.

Based on the result gained trough the inventory a systematic assessment was carried out using environmental factors (EF) and assessment factors (AF). Following the same structure as the projects four environmental factors; waste characteristics, geo-hydrology, surface water and land and nature were chosen.

The environmental factors were further divided into assessment factors with a number of significance (NS) depending on its environmental importance. Due to mathematical reasons the score 1 meant less environmental impact and the score 4 more impact. The NS of each environmental factor was added together to calculate a total number of significance (TNS) (see APPENDIX 30).

The assessments factors were assessed due to criterions 1 to 4 where 1 meant environmentally more unfavourable and 4 less unfavourable. The number of significance and the assessed value of the factor were then used to calculate the value of the environmental factor;

$$EF = \sum \frac{AF \times NS}{TNS}$$

The value of the environmental factor ended up between 1 and 4 where 1 was environmentally more unfavourable and 4 less unfavourable. To mark if there was any uncertainty about the assessment the factor was given an uncertainty number where 1 meant great uncertainty and 4 meant negligible uncertainty.

The calculated value of the environmental factors was then used as guidance and control when the manual environmental assessment was carried out. The classification was then based on the assessment of the different projects, mainly on the assessed value of the environmental factors but also the uncertainty number was taken into consideration. Gokarna was then placed into risk class 1, 2(A), 2(B), 3 or 4 due to following criterions as described below:

Risk class 1: Site where protective measures are considered necessary to clear a concrete environmental conflict so that the landfill could be transferred to class 2(B) or 4

- If any environmental factor is assessed 1
- If there is a concrete environmental conflict and protective measures are necessary

Risk class 2: Site where further investigations need to be carried out to clear if

A) The site should be transferred to class 1 and protective measures need to be carried out
B) After measures carried out according to class 1 or 3 continuous oversight and control is needed

- If any environmental factor is assessed 2 and none 1

Risk class 3: Site where relatively simple measures as cleaning and complementary cover are needed to transfer the site to class 2(B)

- If the landfill is assessed 4 but with uncertainty number 1
- If all five environmental factors are assessed 3 with the uncertainty number 2, 3 or 4

Risk class 4: Site where no further measure or control is assessed necessary

- If all five environmental factors is assessed 4 with the uncertainty number 2, 3 or 4

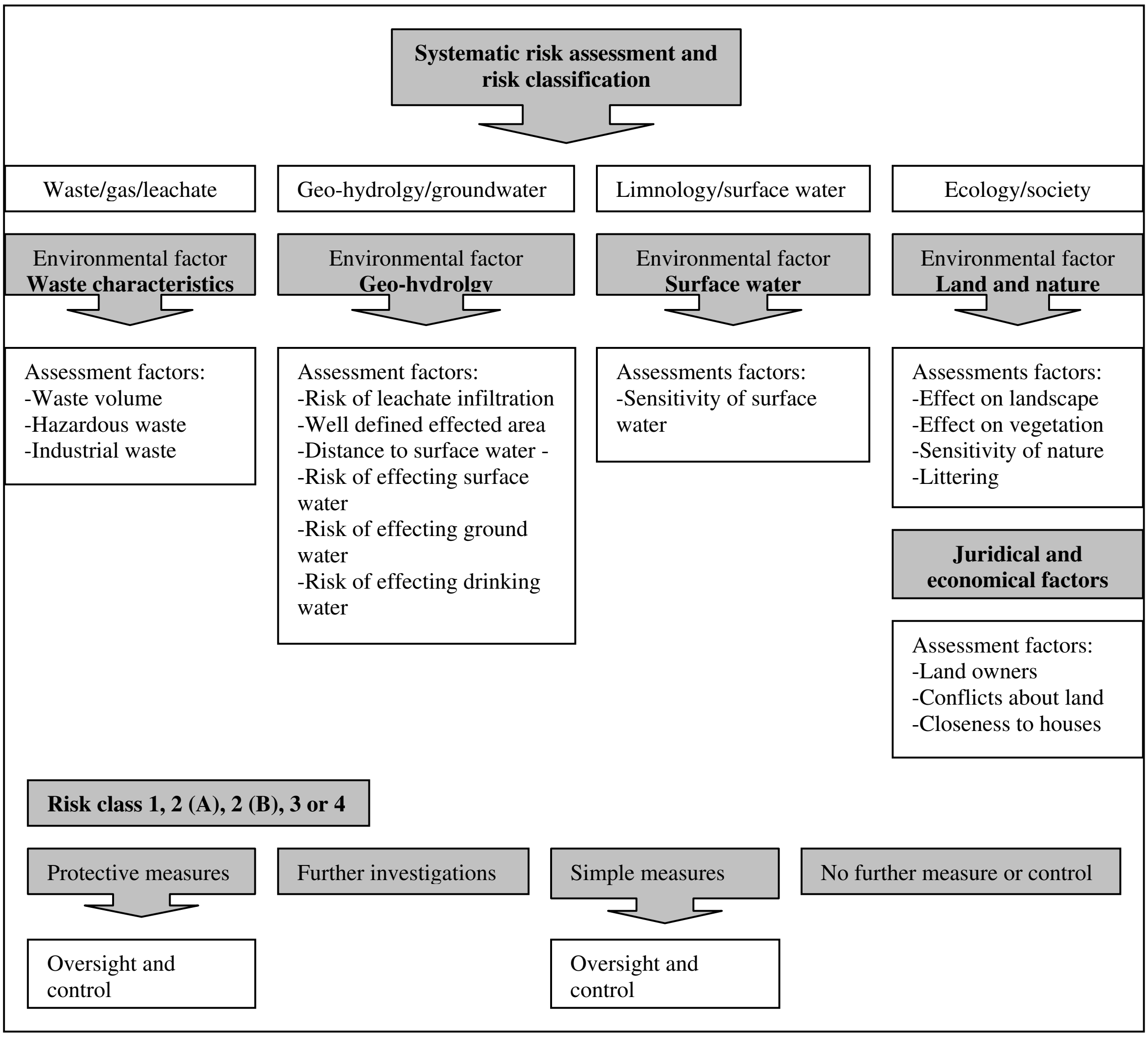

Figure 4.1 The diagram show the different phases of the risk classification of an old landfill according to the Växjö risk assessment model

5 DESCRIPTION OF SITES

5.1 Gokarna landfill site

5.1.1 Location

Gokarna landfill site is located in a narrow valley called Nagdah valley north east of Kathmandu along the road to Sankhu at a distance of 8 km from the center of Katmandu (see APPENDIX 2, Map 3). It is a south-east/north-west valley drained to the west by a small river, Kahare Khola, to Bagmati River. The Valley is about 450 m long and 200 m wide (Oeltzschner and Kharel, 1997) (see APPENDIX 2, Map 1).

5.1.2 Description

Gokarna landfill site is covered with a thin soil cover and only grass is growing (see APPENDIX 1, Picture 11). The top cover of the site is only about two decimeter and consists of soil from the surroundings (Shahi, 2003). The site consists of almost 1 million m^3 of waste (Tuladhar B., 2000) with an average dept of 15 m (Tuladhar A.R., 2003).

The area looks more like a meadow-land used as a play-ground for kids and where goats and cows are grazing (see APPENDIX 1, Picture 12). Settings caused by inadequate compaction and degradation (NESS (P) Ltd, 1996), some were waste can be seen, indicate that the ground consist of waste (see APPENDIX 1 Picture 13). Especially in the lower end of the landfill a lot of waste and litter can be seen (see APPENDIX 1, Picture 14).

At Gokarna landfill site there is no:

- organized gas control, collection or use facilities.
- surface water and drainage facilities.
- control, collection or treatment of leachate.
- sufficient environmental monitoring facilities.
- adequate final cover.
- liner.

(NESS (P) Ltd, 1996)

Downhill, to the west, of the site a wall made of concrete has been built to separate the landfill from the village (see APPENDIX 1, Picture 15). It is only half a meter down in the ground and does not affect the water flow and leachate can still pass underneath the wall (Kharel, 2003).

At many places, slopes surrounding the landfill are vulnerable to landslides as they have been left steep and bare after the excavation of soil for use as cover material (see APPENDIX 1, Picture 12). A gabion wall is constructed at the toe of the slope on the east side of the landfill next to Tiwari village (see APPENDIX 1, Picture 16). This is the most vulnerable part of the landfill as it is next to a dense settlement and is prone to landslides and flow of leachate out from the landfill (Tuladhar B., 2000).

Three monitoring wells downhill on the western side could be found, while the others might be covered with waste.

5.1.3 Geology

The landfill site is walled in by steep 20-30 m high slopes made up of sand and silty layers similar to the landfill sub-soil (Oeltzschner and Kharel, 1997). The ground under the waste has the shape of three or four finger-shaped gorges (Shahi, 2003; Tuladhar A.R., 2003) and consists of different materials, some parts clay and some parts sand (Shahi, 2003) and the bedrock at the site lies about 400 meters down (Kharel, 2003).

Only in the lower parts, first used for landfilling, a foundation consisting of 15 cm of clay with 30-50 cm of gravel on top has been constructed (Tuladhar A.R., 2003). In the other parts of the landfill no kind of liner has been laid (Shahi, 2003).

5.1.4 Around the site

The settlements have become dense around the landfill due to expansion of the nearby villages and growth of the Kathmandu municipality towards Gokarna (Oeltzschner and Kharel, 1997). At the hill to the south of the landfill Mulpani village is located, to the east Tiwari village and to the west, on governmental land, huts have been built by poor people without land (Shahi, 2003).

5.2 Balkhu dumping site

5.2.1 Location and geology

Bagmati River is a 35 km long Holy river that runs from Bagdwar in the north through the valley and the city of Kathmandu (DISVI, 1988) and ends up at Chovar. At Balkhu, where the present waste dumping in Kathmandu is proceeding, the river divides Lalitpur municipality and Kathmandu municipality (Bhujel, 2003) (see APPENDIX 2, Map 3). While flowing downstream many tributaries merge with Bagmati and flow downstream as a single channel (Karki, 2001). The Bagmati River is used as sewage for the inhabitants in Kathmandu and the local industries use the river as a dump for liquid waste (Bhujel, 2003). The riverside of Bagmati is used as a dump all the way through the city and the river is filled with floating waste.

Before the dumping started at Balkhu organized dumping along the Bagmati River has been carried out upstream from Guheshwori (Tuladhar B., 2000) and at Shova Bagvati along Bishnumati River (Karki, 2001). At November 2000 the municipality started the dumping at Balkhu south of the old bridge over Bishnumati River just before the River links with Bagmati River (see APPENDIX 2, Map 4).

The dumping has proceeded south along the river and is permitted to continue all the way to Kirtipur (see APPENDIX 1, Picture 17 and APPENDIX 2, Map 4) (Bhujel, 2003). Along a part of the dumping site a road had to be constructed to facilitate vehicles to reach the dumping site (Bhujel, 2003).

The riverbanks consist of clay material with unknown thickness which may protect the ground water from pollution, though the surface water is totally exposed (Bhujel, 2003). Before the dumping started the 30 m wide riverbanks were totally filled with water during the rainy seasons (Bhujel, 2003).

5.2.2 The dumping procedure

Since there are roads and houses nearby the dumping site, complains have affected the extent of the dumping and the area is not totally filled. When the people in Kathmandu municipality have complained, the dumping has moved to the Lalitpur side of the river and vice versa (see APPENDIX 2, Map 4). Today the municipality and the local people negotiate and the dumping can continue on both sides of the river.

The procedure for dumping has been the same for the entire area (Bhujel, 2003). Initially 30 m long, 10 m wide, and 5-7 meter deep (Bhujel, 2003) trenches are excavated in the river bank to be filled with waste (Manandhar, 2003) (see APPENDIX 1, Picture 18). While filling the trenches with waste chemicals are sprayed from a water tank; when there are problems with flies Novan, an insecticide is sprayed, and lemongrass with water and SuperChi, containing phenols (Bhujel, 2003), is sprayed to reduce the smell (see APPENDIX 1, Picture 19). Sometimes Effective Microorganism is used to speed up the degradation and reduce the volume of the waste (Rajesh, 2003; Bhujel, 2003).

After filling up the trenches with waste some decimeters of the excavated soil is put on top as a cover and the riverbank is compacted regularly with a dozer (Manandhar, 2003). In rainy season light dozers have to be used for compaction to minimize the risks of erosion (Manandhar, 2003). After some rainy seasons the older parts of the dumping site usually sink in height. To level the ground, soil is taken from the newer parts of the dumping area and is placed on the older parts (Bhujel, 2003).

5.2.3 Gas collection

The residents along the dumping site have pushed down pipes and collect landfill gas for domestic use. In the newer part of the dumping site, where the waste is 7-8 months old, 4-5 households have pushed down pipes and in the older part 12 households use the gas (Bhujel, 2003).

6 RESULT

6.1 Water quality investigation

6.1.1 Salts

The results from the analyses of salt are shown in APPENDIX 8.

6.1.2 Metals

The results of metals are presented in APPENDIX 9.

6.1.3 Phenols

The levels of the six different phenols analyzed are shown in APPENDIX 10.

6.1.4 PCB and SVOCs

The analysis of PCB and SVOCs at the GC-MS is carried without any assessment of the results. The results will be presented in the main Sida project.

6.1.5 General scan

The general scan of the four chosen samples resulted in APPENDIX 11 where the detected compounds are shown.

6.1.6 TOC and DOC

The results from the analyses of TOC and DOC on the four chosen samples are presented in APPENDIX 12.

6.1.7 Total Phosphorus

The levels of total phosphorus are show in APPENDIX 13.

6.1.8 Ammonia

The results from the ammonia analysis, are presented in APPENDIX 14, and showed that most of the samples had a nitrogen level lower than the lowest detection limit of the used equipment.

6.2 Artificial leachate

To give an account of the possible future leakage from Gokarna landfill site the production of artificial leachate was carried out. The produced liquids from L/S 2 present the amount that theoretically can leach from 100 g soil/waste in 2 years, respectively 10 years for L/S 10.

The liquids have been analyzed together with the other samples but since the results are not comparable the results for the samples HALS2, HBLS2, HALS10 and HBLS10 are shown in APPENDIX 15.

6.3 Waste characteristics

6.3.1 Handpicking analysis at Teku

The result from the handpicking analysis at Teku (see APPENDIX 16) shows that the major part is organic and represents 66.8 weight-% of the generated waste. The paper fraction was 11.0 % and plastic a bit lower, 8.4 %. Almost no hazardous waste appeared in the waste.

The results from the analyses of the waste samples (see APPENDIX 17) show that all the samples contained heavy metals such as zinc, chromium and lead and there were great variations in the three samples. The samples had an average moisture content of 64.9 % (calculated on all samples except sample 4- the fine fraction).

6.3.2 Handpicking analysis of waste from Gokarna landfill site

The result from the separation (see APPENDIX 18) confirmed the high organic fraction observed during excavation. It was 86.3 % before correction in aspect of soil content in the plastic fraction and 90.3 % after the correction.

During the separation three batteries were found. Traces of medical and electrical waste were also found, such as syringes respectively cables.

6.4 Grain size analysis

The results from the analysis of grain size are shown below in Grain size curves and in APPENDIX 19.

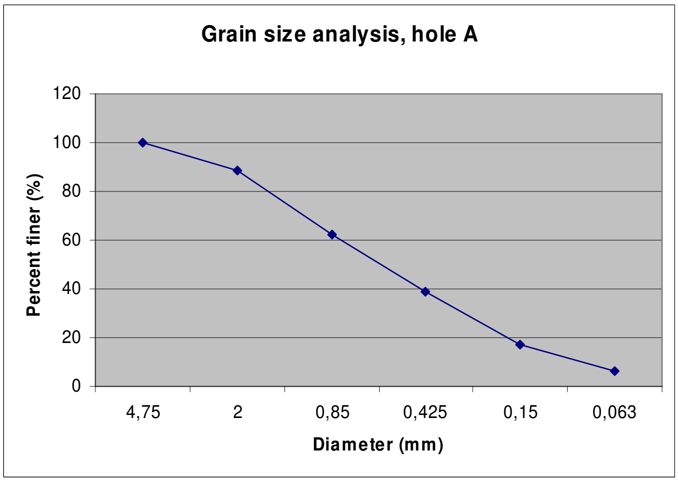

Figure 6.1 Grain size analysis, hole A

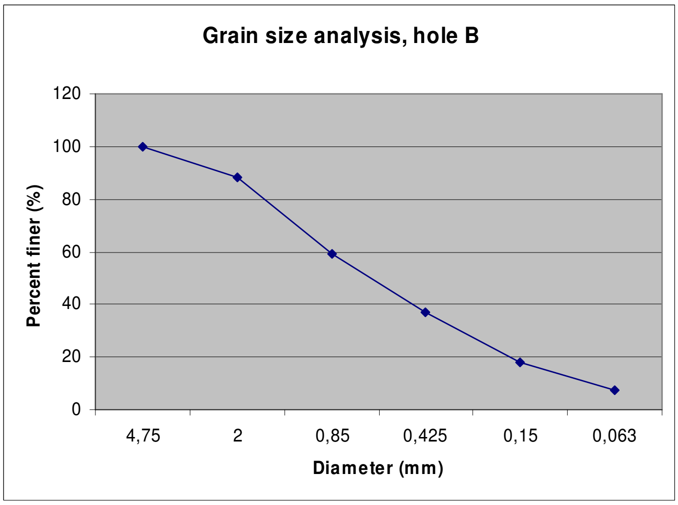

Figure 6.2 Grain size analysis, hole B

6.5 Air quality investigation at Teku Transfer Station

The compounds found in the air samples collected with passive samplers at Teku transfer station are shown in APPENDIX 20. Since the results of the analysis are out of scope the results will be discussed by the main Sida project.

6.6 The Växjö risk assessment model applied on Gokarna landfill site

6.6.1 Project part 1: Waste/Gas/Leachate

6.6.1.1 Waste

6.6.1.1.1 Surface and volume

The Gokarna landfill site is almost rectangular in shape with a surface of approximately 90 000 m^2 (NESS (P) Ltd, 1996). In average the depth of waste is around 15 meters but varies from 5 to 20 meters (Tuladhar A.R., 2003). A calculation based on collected data gives a volume of 1,350,000 m^3 waste landfilled (Tuladhar B., 2000).

The surface has a slight slope and is covered with a few decimeters of soil (Shahi, 2003) with only grass growing upon. The surface is variable due to settings formed after the rainy seasons and caused by inadequate compaction. In some settings small brooks run and during monsoon there is stationary water (see APPENDIX 1, Picture 12).

6.6.1.1.2 Visible waste/litter

Waste and litter can be seen along the settings and small brooks at the site as well as in the lower, western end of the landfill, where dumping was carried out most recently and the surface has not been properly covered (see APPENDIX 1, Picture 20).

6.6.1.1.3 Waste composition

A part of the recoverable materials, paper, metals and plastic, has been sorted out at the transfer station by scavengers (Tuladhar A.R., 2003). Still there are different types of waste landfilled at Gokarna and during the excavation in October 2003 certain materials as textile, plastic bags, shoes, plastic bottles, glass bottles, traces of medical waste (syringes and drug bottles), batteries, construction material, tires, packages, paint tubes, old pens and aluminum cans were observed. The organic waste/soil was estimated to represent the largest fraction. After closure of the compost plant in 1992, that had composted almost 60 % of the generated waste, a greater fraction of organic waste was landfilled (Shahi, 2003). The handpicking analysis of waste from Gokarna landfill site showed that the fraction of organic waste/soil was 90.3 % (see APPENDIX 18).

Containers were provided at the industry area and by the hospitals and the waste collected were transported to the landfill (Shahi, 2003). During the time of operation a few industries producing hazardous waste were active, for example battery and carpet dying industries. Though the risk can not be eliminated, not a great deal of industrial waste is dumped in the landfill. Special waste for example slaughter waste, killed street dogs and outdated medicines etc. was landfilled in places of the site separated from other waste (Shahi, 2003). It can not be excluded that there may be toxic industrial, slaughter or medical waste landfilled at the site (Shahi, 2003).

6.6.1.2 Gas

There is no gas control at Gokarna landfill site, neither during the time of operation. Since closure surrounding households use a small amount of gas. Two households have achieved a continuous flow of landfill gas, used for cooking purpose, simply by pushing down tubes about three decimeters down into the site.

6.6.1.3 Leachate

The leachate production in landfills depends on the infiltration, leakage and the waste amount and characteristics. There are no studies of the leachate production of Gokarna landfill site and only a few analyses of the water quality have been carried out.

Since no leachate could be found by deep excavation in October 2003, artificial leachate was created by a two stage batch test to analyze the possible leakage of pollutants from Gokarna landfill site. The results showed that the risk of pollutants to leak from Gokarna landfill site can not be excluded (see APPENDIX 15).

The analyses of sample 9 taken from the channelling pipe show that 9 parameters out of 19 have levels that are similar to typical Swedish leachate (see APPENDIX 21 and APPENDIX 22). The levels of metals and salts are generally higher in sample 9 than the rest of the samples taken in the surrounding of Gokarna landfill site. A comparison between a sample taken in the same place in 1996 and sample 9 shows that there were higher levels of all parameters except chloride and phosphorus. The reason to this may be that the leachate production was higher in 1996 or that the leachate now has a different path (see APPENDIX 24).

It is difficult to, by the results, assess if the leachate of Gokarna landfill site has affected the surroundings and to what extent. Samples taken in different roar pumps used for drinking water show that the water has values that are similar to WHO guide values for drinking water of parameters of significance to health (see APPENDIX 27).

6.6.2 Risk assessment

The information collected during part 1 is used for the assessment of the potential environmental risk of the waste land filled at Gokarna landfill site of environmental factor “waste characteristics” (see APPENDIX 23). The criterions are chosen to assess what threat the site is to the surroundings and the criterion of volume and risk of hazardous waste is given the highest number of significance. The environmental factor is assessed to 2 based on the calculated environmental factor of 1.8 since the amount of waste is great and the presence industrial or hazardous waste is uncertain but can not be excluded. The analyses of artificial leachate and the liquid from the channelling pipe did not show high concentrations of pollutants. The investigation is done with a moderate uncertainty, 2.

6.6.3 Project part 2: Geology/Ground water

Geo-hydrologically Gokarna landfill site is not a proper place for dumping (Kharel, 2003). The site is walled in by steep 20-30 m high slopes made up of sand and silty layers similar to the landfill sub-soil (Oeltzschner and Kharel, 1997). The top layer in the entire valley consists of 10 – 15 meters of sand (Kharel, 2003). Leachate might infiltrate through the sandy layer since no liner is laid and the site do not have an adequate cover. Villages in the area surrounding the site is using the ground water for drinking and washing purposes and the nearest surface water, Kahare Kola, is located at a distance of 250 meters.

The samples taken downhill, west of the landfill did not show any significant affection from the landfill compared to the samples taken uphill at east (see APPENDIX 24). Neither is there any clear difference in the pollution of the three monitoring wells that are located on different distance from the site (see APPENDIX 26).

Since the geo-situation in the area is not fully understood and examinated and there was not any significant pollution detected in the samples there is a risk that the leachate has run deeper down in the ground than the samplingspots. The leachate could also be moving horizontally through sandy layer instead of vertically which may contaminate the nearby farmland.

6.6.4 Risk assessment

The environmental factor "Geo-hydrology" is meant to show, if the landfill is a threat to the environment due to geo-hydrological circumstances (see APPENDIX 23). The risk of affecting drinking water sources and ground water is given the highest number of significance. 1.4 is the calculated value of the environmental factor but manually the assessment is 2 which means less environmental unfavourable.

The analyses carried out do not show any significant pollution of ground water caused by leachate from Gokarna landfill but since the area that could be affected is not well defined the risk of pollution can not be excluded. The investigation is also carried out with a big uncertainty, 1.

The infiltration from the landfill is assessed to be high and the area of the landfill is large and compounds might have been spread with the groundwater in another direction. Roar pumps close to the site are used for drinking purpose and the risk that leachate do effect the water quality is assessed to be high. Since the distance to nearest surface water is far and it is already polluted by the waste water from villages, waste dumping etc. the risk of affecting surface water is assessed to be small.

6.6.5 Project part 3: Limnology/Surface water

Before the landfill was constructed the Nagda Valley used to serve as a catchment area for the rain water during the rainy season. Today Gokarna landfill site have no surface water or drainage facilities (NESS (P) Ltd, 1996) and the channeling, constructed to divert the surface water from the waste through the site has not been functional for years. There is no inflow to the pipe and the brook that previously ran through the area has disappeared.

The nearest surface water is the small river Kahare Khola that runs 250 meters west of the landfill site and flows into Bagmati River another 250 meters west of the landfill (see APPENDIX 2, Picture 1). This watercourse is polluted by the village that it passes on its way to Bagmati River and is also used for dumping.

6.6.6 Risk assessment

No samples have been collected and no limnology studies have been carried out at surface waters in the area surrounding Gokarna landfill site and therefore only the sensitivity of the nearest river, Kahare Khola with outflow into Bagmati River, has been assessed (see APPENDIX 23) in the aspect of:

- The size and flow
- Distance to larger water system
- Use as recipient, drinking water, recreation and other interests
- Other circumstances upstream or downstream

Kahare Khola flows far from the landfill and is polluted by other sources, why impact caused by Gokarna landfill site is difficult to measure. It is not used for drinking or recreation purposes and 250 meters further down it join Bagmati River. The environmental factor is 3, but with a big uncertainty, 1, since no measurements been carried out.

6.6.7 Project part 4: Ecology/Society

6.6.7.1 Laws and regulations

Environmental Protection Act, 1997, and Environment Protection Rules, 1997, published for Ministry of Population and Environment present laws and regulations concerning solid waste management. In addition SWM&RMC Act contain rules and laws about solid waste management. Even though laws exist no proper enforcement is practiced (Shakya, 2003).

6.6.7.2 Nagdaha Valley before landfilling

Before Gokarna landfill was constructed, the Nagdaha Valley was not used for either agriculture or forestry (Oeltzschner and Kharel, 1997). Almost nothing grew in the area and there was no other interested party to the ground (Tuladhar A.R., 2003). Jurapati, Tiwari and Mulpani Villages already existed before the construction of Gokarna landfill (Tuladhar A.R., 2003) but from the beginning there were only 3-4 houses in "Mulpani 8", and only a few in Tiwari and Jurapati village (Shahi, 2003). The Valley was mainly surrounded by agricultural land.

During the first time of operation no households in surrounding villages complained since they gained from the site, such as jobs with construction and maintenance. During this time the site also was well managed and maintained (Tuladhar A.R., 2003).

6.6.7.3 Changes of nature and landscape

The Valley is now filled up with waste what can be seen as a barrier and the water flow has changed direction or is percolating through the landfill (Tuladhar A.R., 2003). The landscape has changed from being a Valley that lead water catched by the surrounding hills, into a flat land where nothing except grass is growing in the thin layer of soil on top of the site. In some places the area are littered and waste can be seen (see *2.7.2.1.2*) (see APPENDIX 1, Picture 20). The site is still surrounded by agricultural land though the surrounding settlements have expanded.

6.6.7.4 Changes of surrounding villages

The villages, Tiwari, Jurapati and Mulpani, surrounding the Valley have expanded and settlements have become dense around the landfill site (Oeltzschner and Kharel, 1997). Additionally , directly to the west, downhill the site, huts have been built on governmental land by poor people without property (Shahi, 2003). The expansion is mainly caused by urbanization and the growth of the Kathmandu municipality towards Nagdaha Valley (Oeltzschner and Kharel, 1997) but also the construction of the approach road entice people to move to the area (Shahi, 2003).

During periods when the landfill was badly maintained residents, including new residents, from Tiwari, Jurapati and Mulpani village complained loudly. Very few complains came from the area in the west were poor, uneducated people lived on governmental land (Shahi, 2003). Inhabitants in the surrounding villages are positive to SWM&RMC's idea of turning the area into a playground or a park, but oppose plans that imply filling the site with more waste (see APPENDIX 25).

6.6.8 Risk assessment

The aim of the project ecology/society is to assess the visible impact the landfill has to the landscape (see APPENDIX 23). The calculated environmental factor is 2.2 and the factor given by manual assessment is 2. The landfill has a visible impact to the landscape since the entire Valley is filled with waste. Inadequate cover and compaction have created settings where litter can be seen. It can not be excluded that the agricultural land surrounding the landfill is sensitive to the activities proceeding in the area.

Parallel with Project 4, Ecology/Society, conflicts about land and neighbouring villages have been investigated. The information gained about economical and juridical aspects is meant to be used for future environmental protection action plans and will not be a part of the environmental assessment and risk classification. The result shows that there have been many conflicts between the management, SWM&RMC and later KMC, of Gokarna landfill and neighbouring villages close to the site. Today SWM&RMC is responsible for the site and any changes of the area need to be carried out in close co-operation and confidence with people in living in the surroundings.

6.6.9 Risk classification

The risk assessment of the environmental factors carried out does not show that Gokarna landfill site constitute a concrete environmental conflict as class 1 (see APPENDIX 23). All environmental factors except "Surface water" is assessed 2. Gokarna landfill site is therefore classified to risk class 2 and further investigations are required to clear if protective measures need to be carried out. During this project only limited measurement has been carried out since the objective mainly is to evaluate the Växjö risk assessment model. The fact that all investigations have been made with moderate or big uncertainty also give the cause for further investigations.

Table 1: Result from the Risk assessment carried out on Gokarna landfill site

Project1			Project 2			Project 3			Project 4			
Waste characteristics			**Geohydrology**			**Surface water**			**Land and nature**			**RISK CLASS**
CEF	AEF	UN	CEF	AEF	UN	CEF	AEF	UN	CEF	AEF	UN	
1,8	**2**	**2**	**1,4**	**2**	**1**	**3**	**3**	**1**	**2,2**	**2**	**2**	**2**
CEF: Calculated Environmental Factor												
AEF: Assessed Environmental Factor												
UN: Uncertainty Number												

After further investigations the site might be classified as risk class 1 where protective measures are considered necessary or 3 where relatively simple measurements as cleaning and complementary cover are suggested to transfer the site to class 2(B). When the measures are carried out according to class 1 or 3 continuous oversight and control are still needed.

7 DISCUSSION

7.1 Political conflicts

7.1.1 KMC, SWM&RMC and the public

Many of the problems connected to the solid waste management in Kathmandu are basically political and rather institutional and financial than of technical nature. According to Rajesh Manandhar, Section Chief, Solid Waste Management Section, KMC, there are problems with the communication between KMC, SWM&RMC and the public. The parties are not confident with each other, do not co-operate and have no common goal. SWM&RMC is in charge of the decision-making concerning KMC and the decisions depend on the interests of individuals in positions of the ministry. Whenever KMC have new plans they have to ask the ministry about financial and technical support and a great deal depends on the individuals in positions of the ministry and their interests. When positions change the good work might not be continued.

Surya Man Shakya, Environmental Engineer, General Manager of SWM&RMC implies that the individually separated work of the municipalities and the SWM&RMC is sufficient and no co-operation needs to be introduced. He is conscious about the problem of the changing interests of the government and the lack of confidence between the parties. He advocates the importance of universities since people in Kathmandu trust professors more than politicians. At present when there is a lack of confidence towards the government, the universities have to take the responsibility of spreading knowledge about the solid waste management and environmental impact. Through education in environmental issues like waste management interest and consciousness can be based in the young generation.

It is important that how to solve problems connected to rapid development and population growth, for example solid waste management and water pollution, are teached in schools and also are given a central part in media. Information need to be spread through channels as television, radio and papers and also new ways of information spreading needs to be tried out to reach the people. To successfully implement new technologies people need to be aware about the problems and feeling responsible for them being solved.

Since SWM&RMC and KMC have failed too many times the public often is skeptical to new waste management system as for example in the case of “door-to-door collection”. In the end of the GTZ Solid Waste Management Project the maintenance of the waste containers was taken over by the municipality. Since there was not enough capacity to empty them regularly, the people did not want the containers close to their houses anymore, got indignant and developed distrust to the container system. If the confidence between KMC, SWM&RMC and the public would be strengthened, the public could be able to trust and support new plans and improvements of solid waste management systems.

Since no proper enforcement is available, the solid waste management rules and laws in SWM&RMC Act only are partly followed (Shakya, 2003). New plans have no law to lean on and complaints from the public can bring a new investment to an end. The politicians have created the problem and they have to not give in to the public (Tuladhar A.R., 2003).

The work with improvements of the solid waste management is today concentrated to Kathmandu. To improve the situation throughout the country all municipalities need to co-operate. Only in Kathmandu the solid waste management sector has educated staff and more experienced and educated staff is needed all over the country (Manandhar, 2003).

SWM&RMC only working with the support to KMC, but efforts is made to increase the information flow in the entire country and not only concentrating on the situation in Kathmandu. They are also trying to make the environmental work in a long-time perspective and to not be dependent on the individuals’ interests in the ministry.

Community Mobilization Unit, Environment Department, KMC is spreading information about solid waste management in Kathmandu. Since the literacy is low throughout the country alternative ways of spreading knowledge to the public are needed.

7.1.2 New landfill and compost

A sign of bad co-operation is shown by the fact that KMC oppose SWM&RMC's decision to choose Okharpauwa as the location for final disposal of solid waste and compost plant. KMC do not find the solution either economically or practical feasible because of the far distance and the poor road conditions (Manandhar, 2003). KMC also find the Okharpauwa site environmentally unsuitable since it is a huge water catchment's area and consider also the fact that the water flow of the u-shaped river will be changed when constructing the landfill in the valley (Manandhar, 2003).

Rajesh Manandhar claim that KMC for a long time have tried to find a new place for a landfill and was not informed about the government's decision to choose the site. Since the decision was taken during the period of 1 year and 8 months when Kathmandu was without any mayor KMC never had the chance to argue about the decision. Additionally the government had already spent a lot of financial resources (Manandhar, 2003).

The government also signed an agreement with Luna Nepal Chemicals & Fertilizers (P) Ltd to manage a compost plant at Sisdol. Rajesh Manandhar who is skeptical to the far distance and the advanced technology would rather see a solution where a compost plant is situated in central Kathmandu. He advocates only sending a small part of the solid waste for landfilling, for example to Okharpauwa, after sorting out recyclable materials. A suggestion is to construct a compost plant at Chobar, which is located close to Teku transfer station.

Since a lot of confidence from the public was lost along with the closure of the plant at Teku transfers station 1990 it is important that a possible compost plant will work properly this time. Rajesh Manandhar means that if the plans do not work out properly the confidence might be lost forever.

KMC is anxious that people will protest as soon as the landfill has opened and they have been allotted a new road (Manandhar, 2003). The ministry claims that a lot of lessons have been learned from the Gokarna landfill site and the importance of communication between the management and the local people is taken into consideration. At Okharpauwa a committee including local people together with the management of the site will be formed. A greater area than needed for the landfill has been bought as a safety zone, preventing new settlement close to the landfill (Shahi, 2003).

7.1.3 Expectations of the co-operation with JICA

It seems like it is difficult for the municipality to make any plans for the future. KMC do have plans but very bad confidence since only few of their earlier plans have worked out. This is the reason why KMC put confidence in the work and expertise JICA will provide to the waste management in Kathmandu. Hopefully the co-operation will be helpful when making future plans and Rajesh Manandhar, KMC, is of the opinion that the government listens more to plans made by organizations from industrialized countries than to KMC's staff.

A backslash would be if JICA tries to implement technology used in Japan in Kathmandu without thinking of the differences between the countries. High technology solutions that are successful in other countries may probably not work in Nepal (Manandhar, 2003). Besides choosing accurate technology it is also necessary that education of KMC's own staff is carried out. Knowledge should be implemented along with the new technologies. If the local people are not introduced to the new technologies and experiences gained when using the technology it is likely that the project will fail as soon as the responsible organization leaves the project. This is what happened when GTZ left the Gokarna landfill site and the compost plant at

Teku to be managed by the government of Nepal. Enough resources, both financial and personell, to maintain the system implemented need to be available. To avoid meaningless investments when future projects are carried out the history of the solid waste management in Kathmandu need to be considered.

7.2 The dumping of waste at Balkhu

7.2.1 Waste characteristics

7.2.1.1 Waste composition

Even though the physical composition of the Kathmandu municipal waste has changed over the years the result from the waste separation at Teku transfer station showed that the solid waste collected in Kathmandu have a large fraction of organic waste. The percentage of organic fraction was 66.8 % on wet weight basis of the tonne waste separated. Other separations carried out on solid waste from Kathmandu show similar results. In a separation carried out by KMC, 2001, the organic fraction was 69 % and in a study on resource recovery aspects of solid waste carried out 1995 by NESS (P) Ltd the organic fraction was 61 weight-percent. The result on the paper fraction, 11 %, and the plastic fraction, 8.4 %, is also similar to the results given by the studies carried out by NESS and KMC (see APPENDIX 29).

In a comparison made by The World Bank (The World Bank, 1999) the organic waste fraction in urban areas was higher in Nepal than other Asian countries. Cities in countries such as India and China were in 1999 further industrialized than Kathmandu and the organic fraction in these cities had already decreased.

At the separation almost no hazardous waste, except a few batteries, was found. Since only one tonne waste was sorted it can not be excluded that hazardous waste is dumped along the riverbanks at Balkhu.

Industrial solid waste is often sorted and reused at source and no specific industrial waste was found while sorting (Manandhar, 2003). Special treatment of industrial hazardous waste is not available in Kathmandu and will, if not sorted or reused, be dumped along with the municipal waste.

In Kathmandu about 2 tonnes per day of medical waste is generated and since few special treatments are available, medical waste is dumped along with the mixed waste along Bagmati River. During the hand picking analysis no traces of medical waste were found and information gained trough interviews that medical waste is not treated separated.

7.2.1.2 Analyses by NESS (P) Ltd

The results from the analyses carried out by NESS (P) Ltd on waste samples taken at the separation at Teku transfers station show that heavy metals appear in all samples (see APPENDIX 17). Goldsmiths in the city may be the source of mercury and chromium and cadmium may come from tanned leather. The results show that metals may leak and pollute the surrounding area of the dumping along Bagmati River. The results need to be considered in case of incineration or composting of the waste in Kathmandu.

The average calorific value of the waste was 13.3 MJ /kg waste (calculated on all samples except sample 4- the fine fraction) compared with the calorific value of 14.6 MJ /kg waste presented in a report written by NESS (P) Ltd in 1995. This might be an indicator of the decreasing organic fraction.

The average moisture content in the waste at the sampling occasion was 64.9 % (calculated on all samples except sample 4 – the fine fraction) and was in 1995 44 % (Sharma et al., 1995). Any comparison is limited since the report did not tell the time of sampling. The moisture content of the waste varies during the year due to the rainy and dry season and the waste composition depending on festivals and seasons of different types of food.

7.2.2 Water quality investigation

To investigate how the dumping in the river banks at Balkhu affects the water of Bagmati River two samples have been taken upstream, sample 14 and 15, and two downstream, sample 12 and 13, the site at one occasion. Phenols were detected in the samples from both upstream and downstream the dumping site (see APPENDIX 28), especially in sample 14, taken upstream the dumping site in the tributary Bishnumati River. 4-Chlorophenol, an environmental and health hazardous substance, was found in the samples taken downstream but not upstream.

The analysis of total organic carbon (TOC) and dissolved organic carbon (DOC) on sample 12 (downstream the dumping) and sample 15 (upstream the dumping) shows that the TOC level is slightly higher downstream the dumping and the DOC is slightly lower compared to the sample taken upstream (see APPENDIX 12). The high levels of total organic carbon both upstream and downstream the dumping indicates that Bagmati River is highly polluted. Dissolved organic carbon constitutes a part of the total organic carbon together with particulate organic carbon. The results from the analysis of DOC show that the dumping is not the most considerable source of DOC (see APPENDIX 12).

The metal analyses do not show any significant difference in the samples downstream and upstream the dumping site. The heaviest polluted sample is taken upstream, sample 14, taken in Bishnumati River close to where it links with Bagmati River. The levels of copper, calcium and phosphorus are high in all four samples (see APPENDIX 21).

When comparing the levels of different parameters with typical Swedish leachate (Hogland et. al., 1996) from landfills that are in the acid-generating phase or methane-generating phase the levels of Bagmati are far lower in Bagmati River. The water of Bagmati is diluted by water, sewage and different sources of pollution that may explain the result of the comparison. The concentrations may also vary during the year depending on the dilution and pollution in the river.

7.2.3 Environmental impact

The pollution of Bagmati River has increased in recent years due to insufficient waste management as well as due to the urbanisation and insufficient waste water treatment. There is no sewage treatment in the city and waste water is disposed directly into the river. The establishment of carpet, garment, and leather factories within the city area has greatly contributed to the problem since the liquid waste is dumped in the river (Karki, 2001). Furthermore air pollutants, pesticides and fertilizers contribute to the contamination of the water (DISVI, 1988).

Before the organized dumping started at Balkhu a great amount of waste was dumped along the river but not in a concentrated area as today. The metal and salt concentrations in the river have increased since 1995 both upstream and downstream Balkhu which indicates that the dumping only partly contributes to the contamination (Sharma et al., 1995). A comparison between the sample taken upstream and a sample taken one kilometre upstream the dumping site in 1994 indicate that the levels of copper, lead, zinc, cadmium, chromium, nickel, arsenic and mercury have increased radically (Sharma et al., 1995) (see APPENDIX 28). In 1995, before the dumping at Balkhu started, the ammonia concentration was excessively high in the river (Sharma et al., 1995). The values are compared with sample 12, 13, 14 and 15 in APPENDIX 28. It is important to consider that the results from the different analyses depend on a lot of factors as the occasion of sampling and the handling of the samples. The levels of pollutants differ during the year depending on the dilution from rainwater, what type of waste that is dominating in the dumping site and the load of pollutants. Additionally the outcome depends on the sampling methodology, handling, storage and what type of analysis that has been used on the samples.

The analyses of fresh waste showed that all samples contained metals as well as heavy metals (see APPENDIX 17). Since the dumping is in direct contact with the surface water and large amounts of water percolate through the waste during every rainy season, the substances in the waste will eventually reach the river even though the cover and ground material may consist of low permeable clay. Before the dumping started the riverbanks used to be filled up with water during the rainy seasons. Since there is no prevention for heavy rain the river banks are unstable and heavy rains could cause concerns and create landslides.

It is difficult to compare to what grade the dumping contributes to reduce the water quality of Bagmati River. The sampling for water quality carried out did not show any great difference of pollution upstream and downstream the dumping site and the highest grade of pollution was detected in the sample taken upstream in Bishnumati River. Since the study is inadequate with only four samples taken at one occation further investigation is needed to evaluate the environmental impact of the dumping at Balkhu.

7.3 Gokarna landfill site

7.3.1 Water quality investigation

The samples taken around Gokarna landfill site are grouped as following to enable comparisons;

- Monitoring wells (Sample 1, 2 and 5)
- Roar pumps used for drinking water (Sample 3, 4, 6, 7, 8, 10 and 11)
- Channeling pipe (Sample 9)
- Artificial leachate (HALS2, HBLS2, HALS10 & HBLS10)

7.3.1.1 Monitoring wells (Sample 1, 2 and 5)

The samples from the three monitoring wells, that are located on increasing distance from the landfill site, were taken to see if there was any spread of pollutants on different distances from the landfill. By comparing the results it is not possible to tell any significant difference in the composition of the samples (see APPENDIX 26 and APPENDIX 2, Map 1). The reason to this may be that the leachate could be running deeper down in the ground and affect water that is not examined in this study.

Another possibility is that there was not any leachate production at the time of sampling or that the flow of leachate is in another direction. When there is no knowledge of the water flow in the ground it can take a long time before the effects of the leachate appear. It is therefore important to make the geo-hydrological situation clear by an examination.

7.3.1.2 Roar pumps and dug wells used for drinking water (Sample 3, 4, 6, 7, 8, 10 and 11)

Samples from pumps and wells that are used for drinking water have been compared with World Health Organization’s drinking water guide values for chemicals of significance to health (see APPENDIX 27). All the samples fulfil the requirements except sample 4 (roar pump by monitoring well 2) that had too high levels of barium and sample 7 (new dug well upstream Gokarna) that had too high levels of nitrite (see APPENDIX 2, Map 1 and APPENDIX 31. The water in the dug wells may have a different source of contamination than the landfill like running through pipes of zinc or copper (see APPENDIX 31). At a comparison with typical Swedish leachate the levels of phosphorus are low in all samples taken around Gokarna (see APPENDIX 21).

A comparison is made between samples taken on the eastern hill, which is said to be upstream (Kharel, 2003), and samples taken on the western side, downstream, of Gokarna landfill site (see APPENDIX 24 and APPENDIX 2, Map 1). Sample 7 is taken from the new dug well on the hill used for drinking water and sample 10 is from the old dug well. Sample 7 showed higher concentrations of all metals except boron, barium and nickel than sample 10. The newer dug well has higher concentrations of many parameters than samples taken “downstream” while the old dug well has about the same levels as the samples taken “downstream”.

There is a possibility that the leachate has run to the east conflicting with the theory that the groundwater flow is from east to west. Since not enough information is available to make any qualified assessments of where the leachate flows it is important to map the geo-hydrological situation in the valley.

The samples that are taken most far from the landfill site (sample 6 and 8) did not show any clear difference in concentrations from the samples taken closer to the site (see APPENDIX 24). Due to this Gokarna landfill site can be assumed not to be the most important source of pollutant in the area. The surrounding farmland and the households in the growing villages also contribute to the pollution of the valley.

7.3.1.3 Channeling pipe (Sample 9)

Sample 9, taken from the channelling pipe through Gokarna landfill site, shows most similarity to "typical Swedish leachate" in a comparison with 9 high parameters out of the 19 (see APPENDIX 21).

In the analysis of ammonia, most of the samples had a nitrogen level lower than the lowest detection limit of the equipment, possibly due to the long storage of the samples (see APPENDIX 14). Though, the highest concentration was found in Sample 9 which contained 0.051 mg/l of nitrogen which might indicate that the level where greater at the sampling occation.

The results from the report "Environmental Management Plan of the Gokarna landfill site, Kathmandu: Preparation of Base Map and Monitoring of the leachate, Surface and Sub-surface water – Final Report 3/96, Kathmandu", written in March 1996, showed that "the sample taken from the outlet of the drain pipe has all the characteristics of leachate of the solid waste dump". Compared with the results of sample 9 all parameters except chloride and phosphorus were higher in 1996 than 2003 (see APPENDIX 22). The reason to this may be that the leachate production was higher in 1996 or that the pipe has been affected in some way after 1996. Another reason could be that the sample in 1996 was taken in March and the sample 9 was taken in November since the ground water flow and the leachate production depend on the season. The pipe is said to be broken during the mismanagement of the site which means that the leachate has flown in a different direction ever since.

7.3.1.4 Artificial leachate (HALS2, HBLS2, HALS10 and HBLS10)

The four produced samples HALS2, HBLS2, HALS10 and HBLS10 showed to have phosphorus levels similar to typical Swedish leachate, while the chloride and sulphate levels were just under (see APPENDIX 21).

The levels of ammonia in HALS10 and HBLS10 were lower than the lowest detection limit of the used equipment while the levels in HALS2 and HBLS2 were just above (see APPENDIX 15).

In the samples from L/S 2 the concentrations of most of the phenols were high (see APPENDIX 15). No o-creosol was detected in any of the samples.

The samples showed high levels of metals such as copper, nickel, mercury and arsenic. As well as the phosphourous levels the metal concentrations in the samples are similar to "typical Swedish leachate" (Hogland et. al., 1996) (see APPENDIX 21).

7.3.1.5 General scan

With the objective to find any environmental hazardous substances a general scan was carried out on following four samples (see APPENDIX 11);
Sample 4: Roar pump by monitoring well 2
Sample 9: Pipe through landfill
Sample 12: In Bagmati River downstream dumping site
Sample 15: In Bagmati River upstream dumping site

In all the samples different benzene compounds, which belongs to polycyclic aromatic hydrocarbons (PAH), could be detected (see APPENDIX 31). Sample 15, and possibly sample 4 and 9, showed a content of Phenanthrene, a substance that is cancerogenic and poisonous cancerogenic and poisonous and belongs to the PAHs (see APPENDIX 31).

The environmental hazardous substance Dichlorvos/ DDVP from the insecticide Novan, sprayed on the waste masses when dumping at Balkhu could not be detected by the general scan in the samples taken in Bagmati River (see APPENDIX 31).

Different forms of Naphthalene were detected in all four samples as well as Di-n-butyl phthalate and Cyclohexene (or Dipentene) (see APPENDIX 31). All the samples showed to contain Piperidine (or Pyridine) (see APPENDIX 31).

7.3.2 Grain size analysis

As shown in APPENDIX 19 more than 88 % of the soil from both the holes have the grain size between 0.15 – 2 mm. Such a large fraction of fine particles indicates that the waste is far degraded in both the upper and the lower part of the landfill.

A study carried out on soil from a Swedish landfill, Måsalycke Landfill, showed to consist of less than 40 % of soil with grain size below 2 mm (Hogland and Kriipsalu, 2003). The result from the Grain Size analysis shows that the waste in Gokarna landfill site is more degraded than the waste in the Swedish landfill.

The great fine fraction precludes the material of being used for road construction. It is important to be careful when using materials from an old landfill since there is always a risk of spreading the pollutants that the material contains. If the material is totally inert, which is doubtful and has to be examined, it can be used as filling material without any risk of leaching of pollutants.

7.3.3 Evaluation of "The Växjö risk assessment model"

The Växjö risk assessment model has during this project been investigated and tried out on Gokarna landfill site. The result from the risk classification showed that further investigations are needed to clear if the landfill site constitutes a concrete environmental conflict. Measures as cleaning and complementary cover of the site and also continuous oversight and control are due to the investigation required.

Since only limited investigations and analyses have been carried out the outcome that further investigation of the site is needed was not unexpected. Though only a part of the risk assessment model was carried out, the possibilities to use it in a developing country such as Nepal could be evaluated. The suggestions of improvements might be influence by the fact that no comparison between different landfill has been carried out i.e. one of the aims with the model developed model in Växjö was disregarded.

7.3.3.1 Information and measurements

The preparative first phase of the Växjö risk assessment model is necessary to adjust the model after the condition in the country. To clear what financial, personnel and analytical recourses etc. are available in the municipality literature and field studies are required. The studies will be of use to create a suitable program of the environmental inventory of the site.

During the second phase experts are favourable in different areas as geology, chemistry, limnology etc. to carry out the different projects. Since the physical, chemical and biological processes, pollutants inside and around the site and their impact on the environment are complicated, interdisciplinary knowledge is of great importance. The idea of the Växjö risk assessment model to put different knowledge and projects together is necessary to reflect the complex environmental problems caused by old landfills.

It is difficult to get hold of information in Kathmandu, especially in written form and therefore interviews are measured to be the most successful and fruitful method to collect information as experienced in the first stage of project waste/gas/leachate. The method does not demand either great financial or technical resources which often are of shortage in developing countries. It was useful to get a rough knowledge about the waste composition and what pollutants to suspect. Information that can be used also when investigating other environmental factors, for example does the waste composition affect what compound might be polluting ground and surface waters.

The method suggested by the Växjö project to use old phonebooks to locate possible sources of hazardous waste was not successful since the industries' activities are not given in the phonebook in Nepal. Another point is that probably not all industries in the Valley are represented in the phonebook. A way to get information about what type of solid waste that is produced by industries in the Valley would be to make field visits at industrial areas.

Since it is difficult to find results from sampling and analyses previously carried out, it is necessary to plan the monitoring thoughtfully and find or develop accurate methods for analyses. Enough samples need to be taken in the area surrounding the site to measure the environmental impact to the surroundings. The analyses of some parameters can be very complicated and expensive. Also in this aspect the methodology of investigating the waste composition can be useful to know what compound to search for and avoid carrying out any unnecessary analyses.

The number of uncertainty makes it possible to carry out the inventory and the risk assessment even though expertise, information, lab facilities etc. are insufficient in the country.

7.3.3.2 Risk assessment and classification

Even though only one landfill was investigated and no comparison between landfills was made yet the system of environmental factors has been tried out and investigated.

The idea of the Växjö risk assessment model to split the complex environmental problem caused by old landfills into environmental factors and assessment factors is useful to make sure all aspects have been considered. To systematically sort all the information and the data collected during the inventory gives overview needed to investigate what threat the landfill constitute to its surroundings. To be able to compare different landfills a systematic method is essential.

In case of a comparison, between landfills, more factors can be added or some might be eliminated and even though some factors are excluded, as in this project where no limnology studies where carried out, the fact that surrounding surface can be affected of a landfill is still taken into consideration. If several landfills in a developing country will be compared the environmental factors and the range of assessment factors need to be changed for their conditions. The situation is often more acute and it is important to attend to the most urgent problems in first.

The aim of the model to use a minimum of resources makes it interesting to apply in developing countries such as Nepal. It is essential to put the landfills/dumps in order of precedence and start the work with the most important and urgent environmental measures while considering both the environmental and resource aspect. To investigate which landfill/dump that causes the worst environmental impact gives the possibility to use available resources where they are needed.

The information collected during the inventory and the knowledge gained through the risk assessment and classification will be of use when developing the environmental protection act and therefore it is important that all aspects have been considered. As in the case of Gokarna landfill site; when people live close to the site, aspects of conflicts with neighbouring villages, investigated parallel with the project ecology/society, are important to create suitable environmental action plans.

7.3.4 Suggestions of improvement

7.3.4.1 Alternative 1; Excavation

As a suggestion the waste of Gokarna landfill site could be excavated to enable sorting out materials for recovery and remediation of the area. A feasible excavation assumes available ground to place the excavated material and/or that the landfill contains valuable materials. Alternatively an excavation may be considered necessary to prevent the waste from contaminate the area. An excavation should not be carried out during rainy season.

Handpicking of old waste shows that more than 90 % (see APPENDIX 18) of the landfill consist of organic matter and the degradation has proceeded far. Since some plastics were under degradation and the soil content was high, only a small fraction of the waste in Gokarna landfill site would be possible to sort out. It would be important to find use for the great soil fraction for example for road construction. At present the excavated material is valueless and there is a problem with finding land spaces in Kathmandu, i.e. an excavation of the entire landfill would probably not be feasible. The soil fraction could possibly be used as a final cover material for the landfill site.

Since Gokarna landfill is assessed to risk class 2 (A) (see APPENDIX 23) further studies are needed to asses if a remediation is necessary to protect the area. An excavation may affect the surroundings more than leaving it as it is. A landfill and its surroundings is an affected zone where activities like excavation can affect the composition of the site and start processes where environmentally hazardous substances can leach to the surroundings (Nilsson and Hult, 1990). The simple construction of the landfill makes it risky to start an excavation of Gokarna. The walls in the valley may be fragile and an excavation might be a big risk to the settlements around the landfill.

7.3.4.2 Alternative 2; Reopen

Since it is hard to find available land areas and space for new landfills in Kathmandu reopening the landfill would be an alternative solution; possible to use the spare capacity of Nagda Valley and fill up Gokarna landfill site with more waste. To reopen Gokarna landfill site in combination with a compost plant, that reduces the amount of waste for landfilling, would be better for the environment than to pollute a Valley that yet not has been polluted. With a proper cover on top of the old waste, drainage for leachate and gas as well as treatment and strengthened walls, Gokarna as a landfill site would be greatly improved.

Few studies of the possibility of filling up Gokarna landfill site with more waste have been carried out (Tuladhar B., 2000). In 1998 a case study was made to evaluate the possibility to fill up Gokarna with more waste with the conclusion that Gokarna landfill site, with approval from the local people, could be used for another 10 or 15 years (Manandhar, 2003). In the north-east corner of the landfill site there is a trench that can be filled up and in the south-east corner the level can be raised by about 5 meters. It would be possible to fill up with a significant amount of waste in case the level of the landfill was raised and formed like a hill in the middle (Tuladhar B., 2000).

The protests from the local people against reopening the landfill site could play a decisive role. The people that lived around the landfill during the time of operation have lost their faith in a proper management of the landfill site and additionally the villages close to Gokarna have expanded since the landfill was shut down. Interviews with people living around the landfill showed that the people would not allow a reopening of the landfill site (see APPENDIX 25). Due to political reasons it is impossible to move the people from their homes to enable continued dumping at the site. A change of the law is needed to reopen Gokarna landfill site against the peoples will (Ranjitkar, 2003).

7.3.4.3 Alternative 3; Proper closure

Due to the results from the analyses that do not show any higher levels of pollution (see APPENDIX 27) and the assessment to risk class 2, further investigations are required to clear if protective measures need to be carried out (see APPENDIX 23 and APPENDIX 7). Another alternative is to finish Gokarna landfill site in a proper way with a sufficient cover. The rain water would have to be lead through ditches in the middle of the Valley and divert to Kahare Khola to avoid settings in the badly compacted waste.

Since there are already people using the gas in the old parts of the landfill it would be simple to make the use more efficient. By pushing down supplementary pipes in the same simple way as the residents have done further more households around the landfill site could receive gas. Further studies need to be carried out to investigate the amount of gas Gokarna landfill site is producing and the interest of the recipients. If there is a demand and enough gas production a test pumping of gas would be justified.

A majority of the residents around Gokarna landfill site use the area in some way; as pasture for their animals or as a playground. If the surrounding villages could use the area in a better way after a proper closure they could be in favour of the alternative. If their attitudes were positive they could participate in the construction and the work with a proper cover and ditches could create occupation for some of the inhabitants.

Alternative 3 is probably the most popular alternative among people and thereby easiest to carry out. Murali Ranjitkar, Project Coordinator of Solid Waste Management Action Plan, investigates solutions for Gokarna landfill site. A consulant was in January 2004 given the commission to "preparing a post operational management and monitoring planning of the Gokarna landfill site to abate the negative environmental impacts in and around the Gokarna landfill site" (Ranjitkar, 2003). The study will be finished in June 2004. According to Murali the most popular suggestions are to make a golf course, play ground, cricket ground, garden or a resort on top of Gokarna landfill site (Ranjitkar, 2003). Since a home of children without parents are built on top of the hill just east of the site, as a suggestion the space on top of the site could be used as a field laboratory where the children could practice and increase the interest in environmental science and technology. Since the waste compaction is insufficient it would not be possible to construct any heavy buildings on top of the site.

8 CONCLUSIONS

The conclusions can be summarized in 21 concluding remarks;

<u>Gokarna landfill site</u>

1. Gokarna landfill is classified as 2(B) and further investigations are needed to clear if the site constitutes a concrete environmental conflict. Measures as cleaning and complementary cover of the site and also continuous oversight and control are due to the investigation needed.

2. To finish Gokarna landfill site in a proper way with cover and treatment seems to be the best alternative for the site. The area could then be used for example as a recreation area or playground.

3. Since there is no knowledge of the water flow in surrounding ground it is important to map the geo-hydrological situation to clear the effects of the leachate from the site.

4. Gokarna landfill site consists mainly of organic materials. The soil has a large fraction of fine particle size which indicates a far proceeded degradation.

<u>The dumping at Balkhu along Bagmati River</u>

5. Without any improved construction the dumping at Balkhu along Bagmati River is a serious environmental threat that can not proceed. The waste that is dumped contains heavy metals that eventually will leak to the surface water.

6. Even though no hazardous or hospital waste was found during the handpicking analysis there is a risk that such types of waste will be dumped at Balkhu from trucks that were not covered by the analysis.

7. The pollution of Bagmati River has increased during the last decade but without furthers studies it is difficult to assess to what extent the dumping causes the pollution.

8. It is important to consider that the outcome of different analyses depends on many factors. The levels of pollutants differ during the year depending on the dilution from rainwater, what type of waste that is dominating in the dumping site and the load of pollutants. Additionally the outcome depends on the sampling methodology, handling, storage and what type of analysis that has been used on the samples.

<u>Solid waste management in Kathmandu</u>

9. The organic fraction of the generated waste in Kathmandu is decreasing. To minimize the problem of finding a new landfill area a compost plant is needed to reduce the volume for landfilling. It is also important to keep the total waste generation per person low.

10. To make any improvements of the solid waste management in Kathmandu, co-operation between the municipality, governmental institutions and the private sectors that does not exist today is necessary.

11. It is necessary to involve the people in environmental issues, such as solid waste management to increase the awareness and knowledge. To avoid environmental consequences caused by improper development education of the people to make them more environmental concerned and interested is necessary.

12. The government and the municipalities have to regain the public's faith to make the public involved and contribute to an improved solid waste management. The trust could be rebuilt by an increased information flow and communication in media such as radio, TV and papers, in schools and other public institutions and in the streets of cities and in villages.

13. Laws and regulations with proper enforcement are needed.

14. According to KMC, Okharpauwa is not a sufficient location for a new landfill due to the far distance from the city, the poor road condition and the lack of transportation resources.

15. To ensure mistakes not being repeated, experience gained from the GTZ Solid waste management project should be considered when future projects are carried out.

<u>The Växjö risk assessment model</u>

16. The preparative phase to create a suitable program of the inventory is essential to clear what financial, personnel and analytical recourses etc. are available in the municipality.

17. To be able to reflect the complex environmental problems caused by old landfills interdisciplinary knowledge is of great importance and experts in subjects as geology, chemistry, limnology etc. are valuable to carry out the different projects.

18. Interviews and field visits at industrial areas are measured to be the most useful and economical preferable methods to locate if there is toxic waste in the landfill. The information gained is also of use to clear what pollutants are threatening the surroundings of the site and what parameters to analyse.

19. The number of uncertainty makes it possible to carry out the inventory and the risk assessment even though expertise, information, lab facilities etc. are insufficient in the country.

20. A systematic model, as the risk assessment model developed in Växjö municipality, does facilitate that all aspects have been considered to get the overview of the environmental impact of the landfill site. To work systematically is essential to be able to compare different landfills.

21. What makes it interesting to use the model in a developing country such as Nepal is that it is meant to be used with a minimum of resources. The way of investigating which landfill/dump that causes the worst environmental impact gives the possibility to use available resources where they are most needed.

9 REMAINING PROBLEMS AND FUTURE RESEARCH

Ultimately following 9 issues for further studies have been identified;

1. Samples should be taken regularly and during the different seasons of the year around Gokarna landfill site to enable a more reliable assessment of the situation. More samples of the water quality in Bagmati River would be of great interest.

2. An investigation of the geo-hydrological situation in the valley and its surroundings is important to map the flow of leachate from the site.

3. Further studies about the gas- and leachate production of Gokarna landfill site need to be carried out to enable proper use or treatment.

4. The air quality investigation could be discussed related to the working environment of the scavengers. Studies need to be carried out on the conditions for the scavengers.

5. The results from the scan of PCBs and SVOCs need to be discussed and interpreted. Possibly more samples need to be taken.

6. To further investigate the adjustability of the Växjö risk assessment model a comparison between different landfills needs to be carried out.

7. Further projects financed by Sida could favourable concentrate their work in other developing municipalities within Nepal. An education program may prevent the mistakes made in Kathmandu municipality.

8. An important issue is to concentrate on ideas and research of how to keep waste generation in Nepal low to minimize the amount of waste to be landfilled.

9. To investigate what media or other information channel that would be the best way to inform the public about solid waste management and other environmental issues is of need to involve the people of Nepal in these issues.

10 REFERENCES

Aust, H., Kharel, B. D., Singh, V.K., Jager, S., Jnawali, B.M., Busch, K., 1999, Potential Areas for Waste Disposal in the Kathmandu Valley, Nepal, pages 143-151

DISVI, 1988, Pollution Monitoring of the Bagmati River, Preliminary Report

EUROPEAN STANDARD EN 12457-3, 2002, “Characterisation of waste – Leaching – Compliance test for leaching of granular waste materials and sludges – Part 3: Two stage batch test at a liquid to solid ratio of 2 l/kg and 8 l/kg for materials with high solid content and with particle size below 4 mm (without or with size reduction)”

Hogland, W., Jönsson, Å., Berndtsson, R., Larson, M., Skarström, M., 1990, Miljöskyddsplan för avfallsupplag i Växjö kommun, delprojekt 1 ”Avfall/Gas/Lakvatten”-Etapp 1; Avfall, Avfallshantering och återvinning institutionen för teknisk vattenresurslära, Lunds tekniska och naturvetenskapliga högskola, Lunds universitet, Rapport 3134, Lund 1990, Internrapport 1990:3 (112 pages)

Hogland, W., et al., 1996, Kompendium i deponering, Avfallshantering & Återvinning, Institutionen för Teknisk Vattenresurslära, Lunds Tekniska Högskola

Hogland, W., Kriipsalu, M., 2003, Excavation of Cover Material from Old Landfills, University of Kalmar, Sweden, Dhir, R.K., Newlands, M.D., Dyer, T.D., Sustainable Waste Management (pages 311 – 321)

Jain, N.C., Jain, P.K., Prakash, S., 1984, Engineering Soil Testing, Roorkee Press 247667 (U.P.)

Hogland, W., 1989, A methodology for establishing environmental plans for old landfills, James, J., Niemczynowicz, J., 1992, Water, Development and the Environment, Proceedings of the International Symposium on Water, Development and the Environment, Lund, Sweden April 27-28 (381 pages)

Karki, S., 2001, MSc 2nd Year, Environmental Science, Central Department of Environmental Science, Riverside Dumping of Solid Waste and Bagmati River Environment at Balkhu Area, A proposal submitted to Kathmandu Municipality Solid Waste Management Section (8 pages)

KMC, 1999, Ministry of Local Development (MLD), Kathmandu Metropolitan City, Terms of Reference for Study on the Solid Waste Management for the Kathmandu Valley in Nepal.

KMC, 2003, Not Published Information, Kathmandu Metropolitan City

Mallard, W.G., Reed, J., 1997, AMDIS – USER GUIDE, U.S. Department of Commerce, Technology Administration, National Institute of Standards and Technology (NIST), Standard Reference Data Program, Gaithersburg, MD 20899 (57 pages)

NESS (P) Ltd., 1996, Environmental management plan of the Gokarna Landfill site, Kathmandu, Preparation of Base map and monitoring of the leachate, surface and sub-surface waters, Final Report (74 pages)

Nilsson, S., Hult, J., 1990, Inventering och riskklassning av äldre avfallsupplag, Växjöprojektet, underlagsrapport- 90-talets avfallshantering, Naturvårdverket rapport 3858 (51 pages)

Oeltzschner, H., Kharel, B.D., 1997, Hydrogeological & Geotechnical aspects of the final operation, closure & restoration of Gokarna landfill site, Kathmandu

Sharma, T., Devkota, S.R, Paudel, A., Ranjkar, M.L, 1995 NESS research on environmental pollution and management, a publication of Nepal Environmental and Scientific Services (P) Ltd., Kathmandu, Nepal

SVENSK STANDARD SS-EN ISO 10304-2, 1995, ”Water quality – Determination of dissolved anions by liquid chromatography of ions – Part 2: Determination of bromide, chloride, nitrate, nitrite, orthophosphate and sulfate in waste water, Box 3295, 103 66 Stockholm, tel 08-6135200

SWM&RMC, KMC, LNC&F (P) Ltd., 2003, Agreement for setting up project for processing of Kathmandu’s non-hazardous municipal solid waste on build-own-operate basis between SWM&RMC, KMC and Luna Nepal Chemicals & Fertilizers (P) Ltd 2003

SWM&RMC, 2003, His Majesty’s Government of Nepal, Minstry of Local Development, Solid Waste Management and Resource Mobilization Center, Shree Mahal, Pulchowk, Lalitpur, August 2003, Terms of Reference, Consultancy Services for Environment Management Plan for Gokarna Landfill Site (4 pages)

The International Bank for Reconstruction and Development, The World Bank, Urban Development Sector Unit, East Asia and Pacific Region, 1999, What a Waste: Solid Waste Management in Asia (43 pages)

Tuladhar, B., 2000, Preliminary Assessment of Gokarna Landfill, Kathmandu Valley Mapping Programme (10 pages)

Tuladhar, B., 2001, Solid waste management in Kathmandu (8 pages)

Tuladhar, A.R., Construction Measure, Dumping Site Gokarna, SWMB, GTZ, Report on Gokarna Dumping Site

Ui, 2002, Utrikespolitiska institutet, Länder I fickformat nr 819 Nepal/Bhutan, ISBN 91-7183-821-x (33 pages)

WHO, 1993, World Health Organization drinking water guide values for chemicals of significance to health, reproduced from WHO with permission of the World Health Organization, Geneva

Interviews

Bhujel, M.B., 2003, Interview with Maheshwor Bahadur Bhujel, Assistant Officer, Balkhu Dumping Site, Environmental Department, Kathmandu Metropolitan City, Kathmandu 27 Nov 2003

Kharel, B., 2003, Interview with Mr Basudev Kharel, Senior Geologist, Department of Mines and Geology, Kathmandu, Nepal.

Manandhar, R., 2003, Interview with Rajesh Manandhar, Section Chief, Solid Waste Management Section, KMC, Phone: 4231719, Teku transfer station, Kathmandu, 26 Nov, 3 Dec and 8 Dec 2003

Ranjitkar, M., 2003, Interview with Murali Ranjitkar, Engineer of SWM&RMC, Ministry of Local Development, His Majesty’s Government of Nepal, 28 Nov 2003

Shahi, A., 2003, Interviews with Ashok Shahi, Civil Engineer of SWM&RMC, Ministry of Local Development, His Majesty’s Government of Nepal, 28 Nov and 2 Dec 2003

Shakya, S.M., 2003, Interview with Surya Man Shakya, Environmental Engineer, General Manager of SWM&RMC, Ministry of Local Development, His Majesty’s Government of Nepal, 28 Nov 2003

Tuladhar, A.R., 2003, Interview with Ashok Ratna Tuladhar, engineer, 21 Nov 2003

Tuladhar, S.P., 2003, Intererview with Shriju Pradhan Tuladhar, Co-ordinator, Community Mobilization Unit, Environmental Department, KMC, Phone: 977-1-242148, Kathmandu, 8 Dec 2003

Internet

AIT, Asian Institute of Technology, http://www.arrpet.ait.ac.th 19 Feb 2004

Brinkhoff, T., 2001, City population, http://www.citypopulation.de, 19 Feb 2004

Globalis, http://globalis.gvu.unu.edu/, 23 Feb 2004

Lonely Planet, http://www.lonelyplanet.com 19 Feb 2004

APPENDICES

APPENDIX 1; Pictures

APPENDIX 2; Maps

APPENDIX 3; KMC's partners

APPENDIX 4; Waste generation in Kathmandu municipality

APPENDIX 5; Sampling sites

APPENDIX 6; Wards represented in handpicking analysis at Teku Transfer Station

APPENDIX 7; Risk classes

APPENDIX 8; Salt results

APPENDIX 9; Metal results

APPENDIX 10; Phenol results

APPENDIX 11; Results from general scan of water samples

APPENDIX 12; TOC & DOC results

APPENDIX 13; Total phosphorus results

APPENDIX 14; Ammonia results

APPENDIX 15; Results from analyses of artificial leachate

APPENDIX 16; Results from the handpicking analysis at Teku Transfer Station

APPENDIX 17; NESS test certificate

APPENDIX 18; Results from the handpicking analysis at Gokarna landfill site

APPENDIX 19; Results from the grain size analysis

APPENDIX 20; Analysis of air at Teku Transfer Station

APPENDIX 21; Comparison with typical Swedish leachate

APPENDIX 22; Comparison of channeling pipe through Gokarna landfill site

APPENDIX 23; Risk assessment

APPENDIX 24; Comparison of upstream/west & downstream/east of Gokarna

APPENDIX 25; Interviews

APPENDIX 26; Comparison of monitoring wells

APPENDIX 27; Comparison with WHO

APPENDIX 28; Comparison of Bagmati samples

APPENDIX 29; Comparison of waste characteristic

APPENDIX 30; Assessment factors

APPENDIX 31; Compounds