Hazardous waste management in a natural heritage site: A case study from the Sagarmatha National Park and Buffer Zone in Nepal

Masterarbeit

zur Erlangung des akademischen Grades „Diplom-Ingenieur“

Universität für Bodenkultur Wien
Institut für Meteorologie
Umwelt- und Bioressourcenmanagement

Paul Lichtberger, BSc
Matrikel-Nr. 0640091

1. Betreuerin: O. Univ. Prof. Dr. phil. Helga Kromp-Kolb
H81400 Institut für Meteorologie
Universität für Bodenkultur

Und

2. Betreuer: AO. Univ. Prof. Dr. Kurt Luger
Abteilung Transkulturelle Kommunikation
Universität Salzburg

Sommersemester 2015
Wien, Juni 2015

Zusammenfassung

Gefährlicher Abfall (z.B.: Batterien oder medizinischer Abfall) bildet einen geringen jedoch hochwirksamen Anteil des Abfallaufkommens im Sagarmatha Nationalpark im Himalaya. In Nepal steht die Sammlung, Behandlung und Entsorgung von gefährlichem Abfall aufgrund der sozio-ökonomischen Verhältnisse nicht im Fokus.

Dieser Fall trifft im Speziellen auf den Sagarmatha Nationalpark und dessen Puffer Zone (SNPPZ) zu. Der Nationalpark zählt zu den Tourismusmagneten des Landes und beherbergt ein einzigartiges Ökosystem.

Ziele dieser Masterarbeit sind:

1) Untersuchung und Beschreibung des vorherrschenden Abfallwirtschaftssystems

2) Möglichkeiten und Evaluierung von Szenarien, welche die untersuchten Probleme bewältigen.

Im ersten Schritt lieferten vor Ort durchgeführte Sortieranalysen von gesammeltem und entsorgtem Abfall erste Informationen über Abfallaufkommen, Zusammensetzung und Entsorgung. Im zweiten Schritt wurde auf Basis der evidenten Daten eine Materialfluss Analyse (MFA) durchgeführt, welche den gesamten Zyklus des gefährlichen Abfalls vom Zeitpunkt vor der Entstehung bis zur Entsorgung darstellt. So konnten mögliche negative Auswirkungen eines ungeeigneten Managements des gefährlichen Abfalls identifiziert werden.

Das gegenwärtige Abfallwirtschaftssystem wird anhand folgender Kriterien evaluiert:

- rechtlicher Hintergrund
- finanzieller Aufwand
- vermiedene Kontaminierung

Schlussendlich werden Empfehlungen für eine Verbesserung der Situation diskutiert.

Identifiziert wurde ein durchschnittlicher Anteil an gefährlichen Abfall von einem Prozent am gesamten Abfallaufkommen und sechs Prozent bei entsorgtem Abfall. Die Arbeit zeigt auf, dass in Bezug auf gefährlichen Abfall die sicherheitstechnischen Erfordernisse den lokalen Anfordernissen nicht entsprechen.

Die entscheidende Veränderung im Umgang mit gefährlichem Abfall entsteht in der Haltungsänderung der Nepalis.

Abstract

Waste and particularly hazardous waste management in natural heritage sites receives increasing attention by different stakeholders. This is particularly the case for the Sagarmatha National Park and Buffer Zone (SNPBZ) in the Himalayas, which not only hosts the highest mountain peaks on Earth, but also a larger number of national and international visitors. The SNPBZ comprises of a unique ecosystem, embedded in a complex socio-cultural and religious setting. The aims of this article are 1) to investigate and assess the current situation of management of hazardous wastes (HW) in the Sagarmatha National Park and Buffer Zone, and 2) to design and evaluate possible future scenarios to overcome identified challenges.

In the first step, data on waste generation, waste composition, and waste disposal practices were collected during a field research in the SNPBZ by sorting analysis of wastes from waste collection and dumpsites. In the second step, based on this data, a material flow analysis (MFA) was applied to detected pathways of HW within the SNPBZ in order to determine negative impacts caused by contamination through inappropriate HW-management.

The current situation was evaluated on framework of the national legal situation regarding HW to international legislation. Finally, suggestions for an improvement (if required) are discussed.

Results show that on average, HW in the SNPBZ is 1% of total wastes generated at various sources. However, at dumpsites the share of HW increases to 6% of wastes disposed. The investigation of current HW management practices in the SNPBZ shows that it doesn´t encounter the demands for a safe and to local conditions adapted waste management. First step to a safe HW management would be a specific definition anchored in the legislation of Nepal. Next step are defined threshold values for leachate and clear-cut requirements on construction technique for sanitary landfills with a basic leachate catchment system. Adjacent is a separated collection and appropriate storage for HW to install in the SNPBZ. Furthermore, an information campaign regarding HW disposal could also have a remarkable impact on the public attitude and would help concerned authorities with their aspired plan of installing a “4R – Rethink, Reuse, Recycle and Recover” – concept in the SNPBZ. However, this alternative challenges authorities for waste again in their proven ability to create a social response and conceive a sustainable engagement in the concerned public.

List of contents

List of tables

List of figures

Acknowledgements

Diese Masterarbeit stellt die Erfüllung eines Lebenstraumes dar. Ich möchte deshalb den folgenden Personen meinen Dank aussprechen, auch wenn diese kurzen Worte nur ansatzweise das wiedergeben, was ich ausdrücken möchte:

Durch die Aufgeschlossenheit und Unterstützung von Frau Univ. Prof. Dr. phil. Kromp-Kolb als Erstbetreuerin kam diese Masterarbeit erst zustande. Ihr Engagement und Enthusiasmus etwas in der Welt zum Besseren zu bewegen, versetzt nicht nur Berge in Bewegung, sondern auch Studierende.

Mit Herrn AO. Univ. Prof. Dr. Kurt Luger als Zweitbetreuer wurde das „nosing around" von Robert Ezra Park, Begründer der Chicago School of Sociology, zur gelebten Wirklichkeit. Danke, dass Sie mir eine Tür zu Nepal öffneten, wie es nur Sie mit der NGO ECO HIMAL konnten. Ihre Anregungen und Ideen haben mir neue Horizonte gezeigt.

Es sind Menschen wie Herr Dr. Jakob Lederer, die mir Glauben und Mut gaben, diese Masterarbeit durchzuführen. Mein Dank gilt Dir als Mensch, Student und schlussendlich als Freund. Danke, für alles was Du für mich getan hast!

Meinen Eltern Gerda und Heinz Lichtberger: Die Dankbarkeit, die ich empfinde, lässt sich nicht beschreiben. Euer steter und unerschütterlicher Rückhalt bereichern mich und sind von unschätzbarem Wert für mich. Danke, dass ihr immer für mich da wart und seid!

Mit Valerie Kleinschmid darf ich das Glück erfahren, einen Menschen an meiner Seite zu wissen, der mir unendlich viel Liebe, Kraft und Motivation gibt. Danke, dass du meine Welt hinterfragst und auf den Kopf stellst. Dein Wille und deine Liebe sind Quellen für das Schöne in meinem Leben. Nicht zuletzt gabst du mir den treuesten Begleiter mit auf Reisen: Mooses.

Danke meinem Bruder Alexander, von dem ich lernen durfte, stets das Positive und Schöne in den Menschen und dem Leben zu sehen. Abschließend möchte ich hier noch all meinen FreundInnen danken. Für eure Zeit, dass ihr da seid und dem Lachen, dass ihr mit euch bringt.

Many thanks are going to Sir Phinjo Sherpa, Country Director of the NGO ECO HIMAL for providing the information and help for the field study in the SNPBZ.

Special thanks are going to Miss Lakpa Sherpa, the first person who I was honoured to share my first Dal Bhat with. Thank you so much for spending your time with undertaking surveys for my field study and helping me in the SNPBZ.

List of Abbreviations and Acronyms

3R	Reuse, Reduce, Recycle
4R	Rethink, Reuse, Recycle, Recover
A	Ash
BHW	Burnt hazardous waste
BW	Burnable Waste
CBO	Community based organisation
Cd	Cadmium
CLFs	Compact fluorescent light bulbs
CO^2	Carbon Dioxide
Cr VI	Chrome VI
CV	strived coefficient of variation
DDC	District Development Committee
DIS	Disposal
E	Export
e.g.	Exempli gratia
EPA	Environmental Protection Agency
EPA, 1997	Environment Protection Act, 1997
ESA	Everest Summiteers Association
EU	European Union
EWC	European waste catalogue
FAO	Food and Agriculture Organization of the United Nations
GC	Gas cartridges
GDP	Gross domestic product
Hg	Mercury
HW	Hazardous waste
I	Import
IEA,1992	Industrial Enterprises Act, 1992
L	Leachate
MFA	Material Flow Analysis
MGLC	Maximum ground level concentration
Mn	Manganese
MoCTCA	Ministry of Culture Tourism and Civil Aviation
NBW	Non-burnable waste
NGO	Non-governmental organisation
NGO	Non-governmental organisation
Ni	Nickel

NMA	Nepal Mountaineering Association
No.	Number
OECD	Organisation for Economic Co-operation and Development
OG	Off Gas
Pb	Lead
PCB	Polycyclic chromatic biphenyl
PPP	Purchase power parity
RCRA	Resource Conservation and Recovery Act
RE	Return of full gas cartridges
SAARC	South Asian Association for Regional Cooperation (SEITE 36)
SAME	Saving Mount Everest Report
SNPBMC	Sagarmatha national park, buffer zone management committee
SNPBZ	Sagaramatha national park and buffer zone
SPCC	Sagarmatha Pollution Control Committee
SWMA 2011	Solid waste management act 2011
T	Trade
TAAN	Trekking Agencies Association Nepal
UHW	Unburned hazardous waste
UN	United Nations
UNEP	United Nations Environment Programme
VDC	Village development committees
W	Waste
WHO	World Health organisation
WWF	World Wide Fund for Nature
Zn	Zinc

Units and currency conversion factors

$	US Dollar
%	Percentage
µm	Micrometre

100 Nepalese Rupees = 1 US Dollar = 0,85 EURO (23.3.2015)

cm^3	Cubic centimetre
ft^2	Square feet
g	Gramm
h	Hour
kg	Kilogram

kg/cap/d	Kilogram per capita and day
km^2	Square Kilometre
l	Litres
m^3	Cubic metres
ºC	Celsius Degrees
Rs	Nepalese Rupees
USD/capita/year	US Dollar per capita and year

1. Introduction

1.1 General

Tourism in mountainous regions has a long history and reflects the desire of being the first who put a foot in an untouched scenery and landscape. Especially for the region around Mount Everest, the first presumption of an untapped nature has its validation. The current situation in the Khumbu Region shows a different picture for the “Sagarmatha National Park and Buffer Zone (SNPBZ)”. Since these very first attempts to reach the highest point in the world, more than 5.700 Mountaineers stood on top of Mount Everest.

As a consequence of hosting more than 35.000 visitors a year and a population of 7.616 inhabitants, a whole spectrum of cultural, economic, and ecologic factors impact the sensitive environment of this high altitude area.

With the uprising tourism industry in the remote area of the SNPBZ, also the demand for goods which become hazardous waste like, light bulbs, batteries, gas cartridges and medical supplies are rising.

Waste management in this specific area is in a framework of strained finance of a low income country, geographical characteristics and social demands for living conditions the Himalaya ranges. The first solid waste management scheme in this region was investigated by the NGO ECO Himal. The report with the title “Saving Mount Everest – Managing the solid waste of Sagarmatha national park and its buffer zone” provides a fundamental information about the challenges and chances on solid waste in the framework of the natural heritage site around the Mount Everest. Only with this report on the general solid waste management, this thesis on the unobvious and unknown part on the share and amount of produced hazardous waste in the SNPBZ was possible.

Hazardous waste, as small share of the general waste stream, has the ability, due its specific nature to influence negatively the environment in a short- and long-term. In order to take an international definition on hazardous waste from the Basel convention, hazardous waste is distinguished into 45 different categories.

Current investigations on the treatment of waste in the Sagarmatha National Park Show, that there is no explicit hazardous waste treatment and is mixed in with general waste.

This thesis is the search for different passable scenarios for an appropriate treatment within Sagarmatha National Park and Buffer Zone.

1.2 Research questions

(1) Which quantities of hazardous waste are generated in the Sagarmatha National Park and Buffer Zone?
(2) How is hazardous waste currently treated and disposed-off?
(3) What are the problems regarding the current treatment and disposal of hazardous waste?
(4) Which alternative treatment would be feasible in order to reduce negative impacts from hazardous waste treatment and disposal?

1.3 Research objectives

(1) Analysis and categorisation of hazardous waste in the SNPBZ.
(2) Assessment of the current treatment and disposal of hazardous waste.
(3) Evaluation of negative impacts from the existing treatment of hazardous waste.
(4) Designing different scenarios of treatment and disposal for hazardous waste under in the spirit of environmental conservation and livelihood for humans.
(5) Feasibility assessment on the basis of economical and organisational parameters.

1.4 General outline of thesis

The work in this thesis is divided in different sections to approach the theme of hazardous waste under different perspectives. To start, the research questions and objectives are defined. Based on these points the methodology is set up. The background literature review investigates hazardous waste through the lens of legal, environmental and social perspectives. By applying a similar order of methodology to the origin report on the general solid waste, comparability and specialisation was combined.

With the information gained from the past field study, calculations regarding hazardous waste are carried out. By applying the “Material flow analysis” (MFA), an overview on the current and designed scenarios is given. The stocks and flows of hazardous waste are identified in a qualitative manner.

In the designed scenarios, the collected information is compiled into four different scenarios for hazardous waste in the SNPBZ. The scenarios demonstrate different options that correspond with their environmental and financial impacts.

The field research was conducted in cooperation with the NGO ECO Himal and the Sagarmatha Pollution Control Committee.

2. Methodology

2.1 Selection of research area

The “Sagarmatha National Park and Buffer Zone” (SNPBZ), is situated in the rural part of the low-income country Nepal. (Bank, 2014) It is a remote area and to date only reachable by plane and or by a long and arduous hike from Jiri Bazaar. The Sagarmatha National Park was founded in the year 1976 and extended with the Buffer Zone in the year 2002. (UNESCO, 2011)

The waste management in the chosen research area is imbedded into a rigid financial framework and is geographically an almost closed system for goods and the evolving waste. The Sagarmatha National Park and Buffer Zone is a highly visited area for adventurers interested in trekking and mountaineering with an average of 25,500 (Rai, 2014) visitors a year and 7,616 inhabitants. (Statistics, 2012)

This situation, in a high altitude area, covering the highest peaks in the world, creates a unique and complex challenge for hazardous waste management.

The area was selected due the connection between the Technical University Vienna and the Non-governmental organisation ECO Himal, which is well established within in the SNPBZ.

2.2 Selection of methodology

2.2.1 Data and background research

Beside the literature review, different methods are applied. There is a lack of information on hazardous waste in Nepal in general, and the Sagarmatha National Park and Buffer Zone in particular. For information about quantities and characteristics, treatment and disposal of hazardous waste in the Sagarmatha National Park and Buffer Zone, a field study was necessary.

In gathering facts about hazardous waste, its sources and disposal in the national park, examinations (in form of a sort analysis) of the local dumps were conducted.

Information about products which become hazardous waste, were collected through interviews with different stakeholders in the National Park and Buffer Zone. The accomplishment will differ on the surrounding conditions and will be not randomly sampled.

2.2.2 **Stakeholder Analysis**

The stakeholder analysis is applied in order to identify and categorise stakeholders considered with waste management in the SNPBZ. (Reed et al., 2009) The boundaries for the stakeholder analysis are clarified due the focus on waste management within the SNPBZ. The stakeholder analysis determines the concerned stakeholders and their interest in hazardous waste management in the SNPBZ.

Stakeholders are categorised as:

(1) National and local legal authorities:

Stakeholders in this category are authorities and institutions assigned with the execution of laws, regulations and rules by government of Nepal. All actors are affected by the national park and its buffer zone.

(2) Private formal sector:

The private and organized profit-orientated associations are groups with no institutional background. Task in this sector are the protection of the environmental, economic and cultural background of SNPBZ. The private formal sector fills gaps in which the national and local legal authorities are restrained at least due to financial restrictions.

(3) Private informal sector

Adverse to other regions in Nepal, no scavengers or waste pickers were observed during the field wok of this thesis. It was taken into the analysis in perspective of possible future developments.

(4) Service users

Service users are the biggest group of stakeholders and are directly or indirectly responsible for waste management. This sector has no representative in the "National and local legal authorities" or "Private formal sector" but has the highest influence on the existing waste management.

2.2.3 **Waste information**

Recorded waste quantities in the SNPBZ

In position that these values of waste production are simulated, the calculations in this thesis are based on the total collected and recorded waste in major settlements from the SPCC.

Table 1: Total collected waste in major settlements in the SNPBZ (Shahi and Shrestha, 2013) (Own table)

Fiscal Year	Burnable waste (kg)	Non-burnable waste (kg)	Total collected waste (kg)	Burnable waste on total waste (%)	Non burnable waste on total waste (%)
2003/04	149,000	56,000	205,000	73	27
2004/05	229,000	63,000	292,000	78	22
2005/06	195,000	43,000	238,000	82	18
2006/07	160,000	24,000	184,000	87	13
2007/08	176,000	46,000	222,000	79	21
2008/09	157,000	21,000	178,000	88	12
2009/10	187,000	29,000	216,000	87	13
2010/11	146,000	28,000	174,000	84	16
2011/12	152,000	22,000	174,000	87	13
2012/13	158,000	16,000	174,000	91	9
Total	1,709,000	348,000	2,057,000		
Average	170,900	34,800	205,700	84	16

Values from 2005/2006 and 2011/2012 had been interpolated. On average 205,700 kg of waste is collected in the major settlements annually and on average 80% of this waste was burnable and the rest of 20% was non-burnable waste. This includes the waste from residents and the tourism industry.

Waste potential

Information about waste advent are quantities regarding the collected waste. The waste potential describes the total theoretical waste production that can be covered with a waste collection. The waste potential highlights:

- Calculations regarding consequences of the current collection system
- Decisions regarding future waste management
- Outlook on future scenarios
- Basis for designing collection systems. (Lechner, 2004a)

The information for current waste production is based on two studies. The accounted records and a “rough estimation” (Shahi and Shrestha, 2013) on waste production for residence by the SPCC. The first study was conducted by MANFREDI et al. (2010), the second by ZUSER et al. (2011). Both studies focus on the daily average waste production from visitors and residential factors. Information from the literature is applied and combined with socio economic information. The calculations are applied for the years 2003 to 2013.

Residents are estimated at a total of 7,161 inhabitants (Statistics, 2011), including permanent residents within the SNPBZ for 275 days, with 90 days of absence in the winter season.

On average 25,520 (Rai, 2014) visitors per year stay for approximately 10 days (Manfredi et al., 2010) and usually visit in the spring and fall season.

$$W_{pot}(a)_{(Visitor)} = \emptyset[W_{prod}(MANFREDI\ et\ al\ 2010) + W_{prod}(ZUSER\ et\ al\ 2011)] * \emptyset\ Visitor_{(a)} * \emptyset\ Sojourn\ (Visitor)$$

$Wpot(a)_{(Visitor)}$	Annual waste potential, Visitors
$W_{prod}(MANFREDI\ et\ al\ 2010)$	Waste production, Visitor
$W_{prod}(ZUSER\ et\ al\ 2011)$	Waste production, Visitor
$\emptyset\ Visitor_{(a)}$	Average annual number, Visitors
$\emptyset\ Sojourn\ (Visitor)$	Average staying, Visitor

$$Wpot(a)(_{Residence}) = \emptyset[(W_{prod}(MANFREDI\ et\ al\ 2010) + W_{prod}(SHAHI\ and\ SHRESTHA\ 2013)] * Residence(a) * \emptyset\ Sojourm\ (Residence)$$

$W_{pot}(a)(Residence)$	Annual waste potential, Residence
$W_{prod}(MANFREDI\ et\ al\ 2010)$	Waste production, Residence
$W_{prod}(SHAHI\ and\ SHRESTHA\ 2013)$	Waste production, Residence
$Residence(a)$	Residence living permanent in the SNPBZ
$\emptyset\ Sojourm\ (Residence)$	Average staying, Residence

$$W_{pot}(Total) = W_{pot}(a)_{(Visitor)} + W_{pot}(a)(_{Residence})$$

$W_{pot}(Total)$	Total waste potential
$W_{pot}(a)_{(Visitor)}$	Annual waste potential, Visitors
$W_{pot}(a)(Residence)$	Annual waste potential, Residence

$$SPCC_{cov} = \left(\frac{W_{col}(SPCC)}{W_{pot}(Total)}\right) * 100$$

$SPCC_{cov}$	SPCC waste service coverage
$W_{col}(SPCC)$	Collected waste from the SPCC
$W_{pot}(Total)$	Total waste potential

Table 2: Waste production and potential for the SNPBZ (Manfredi et al., 2010) (Zuser et al., 2011; Shahi and Shrestha, 2013) (Own table)

	(Manfredi et al., 2010)	(ZUSER et al., 2011)	(Manfredi et al., 2010)	(Shahi and Shrestha, 2013)
	Visitor	Visitor	Residence	Residence
Waste production (kg/cap/d)	0.123	0.285	0.109	0.200
Average waste production (kg/cap/d)	0.204		0.155	
Waste potential (kg)	246,041		492,382	
Total waste potential (kg)	356,314			
SPCC waste service coverage (%)	58			

The calculated waste production for Visitors with 0.204 kg/d/cap and the 0.155 kg/d/cap for visitors are used in this thesis.

The SPCC covers approximately 60% with its waste collection of the total generated waste, including hazardous waste, in the SNPBZ. 40% of the total produced waste is self-managed by the residents in the national park and its buffer zone.

Sorting analysis at incinerators in Lukla and Namche Bazar

Recorded literature data from the SNPBZ is evaluated and extended by the results from the sorting analysis. This sorting analysis is carried out at the dumps and incinerators, with the focus on the hazardous waste fraction.

A sorting analysis is conducted in order to provide a cost efficient method (Lechner, 2004b), which makes the thesis comparable to previous studies on the solid waste management in the SNPBZ. The sorting analysis is conducted at the incinerators in Lukla and Namche Bazar, which are the main treatment plants for solid waste from the Sagarmatha Pollution Control Committee (SPCC).

The daily collected waste was sorted and delivered directly to the incinerators. The collected waste quantity varies due the mixture of collected waste and the delivered waste by locals. The delivered waste is mixed with the collected waste. The period in which the sorting analysis was conducted was the month of March, which is the beginning of the spring season for visitors in the SNPBZ.

The average sampling size was approximately seven kilogram (kg). This was the size of one “Doko” (Nepalese panier) in which one load of collected waste was delivered at the incinerators. The sorting itself was departed into the fractions:

- Plastic
- Paper
- Metal
- Glass
- Residues
- Hazardous waste

Each fraction was sorted into a bag and weight. After the sorting analysis, the waste was sorted into a burnable and non-burnable waste fraction, which is the common way treatment from the SPCC for the solid waste in the SPCC.

Figure 1: Incinerator in Lukla; (Own figure)

Figure 2: Incinerator in Namche Bazar with typical nepalese panier in front; (Own figure)

In the case of the incinerators, in total 16 waste samplings are carried out. The average sampling size is 7,4 kg, the total volume of all samples was 117,6 kg. Reason for the average size of 7,4 kg was in the normal size of the panniers, in which the collected waste was delivered from the SPCC staff to the incinerators. By using the new delivered material, the actual composition of collected waste was analysed. Otherwise the collected waste is piled up within the incinerator holding area and is manually sorted into burnable and non-burnable waste. With a total size of approximately 120 kg of sorted waste, the total sampling has a share of nearly 0,1% of the annual waste emergence.

Table 3: Hazardous waste share at Incinerators (Own table)

	Lukla		Namche Bazar	
	kg	%	kg	%
Average hazardous waste	0,03	0,45	0,11	1,65
Total hazardous waste	0,29	0,45	0,95	1,65
HW fraction (%)	1			

In average 0,3 kg in Lukla and 0,11 kg in Namche Bazar of hazardous waste was detected in each sampling. In Lukla the hazardous waste fraction is 0,45% and rises in Namche Bazar to 1,65%. In average, a share of 1% hazardous waste on the investigated quantity of solid waste is detected.

$$HW(a) = Waste_{collected}(a) * hw_{Incinerator}$$

$HW(a)$	Annual hazardous waste quantity
$Waste_{collected}(a)$	Annual collected waste
$hw_{Incinerator}$	Hazardous waste share at incinerator

Table 4: Total collected waste from the SPCC with annual hazardous waste share (Shahi and Shrestha, 2013) (Own table)

Fiscal Year	Burnable waste (kg)	Non-burnable waste (kg)	Total collected waste (kg)	Hazardous waste share (kg)
2003/04	149,000	56,000	205,000	2,050
2004/05	229,000	63,000	292,000	2,920
2005/06	195,000	43,000	238,000	2,380
2006/07	160,000	24,000	184,000	1,840
2007/08	176,000	46,000	222,000	2,220
2008/09	157,000	21,000	178,000	1,780
2009/10	187,000	29,000	216,000	2,160
2010/11	146,000	28,000	174,000	1,740
2011/12	152,000	22,000	174,000	1,740
2012/13	158,000	16,000	174,000	1,740
Total	1,709,000	348,000	2,057,000	20,570
Average	170,900	34,800	205,700	2,057

The average quantity of collected hazardous waste by the SPCC is approximately 2,100 kg.

Sorting analysis on dumps between Lukla and Namche Bazar

The investigated dumps are between Lukla and Namche Bazar. Other dumps were not implemented into the investigations because Lukla and Namche Bazar are the main villages for tourists connected through the only possible pathway within the National Park. Dumps that were detected were visited and analysed. Dumps that are located in the dry season, near of riverbanks or dry riverbanks had been washed away by the "Koshi river" during its swelling in the monsoon season. At the location from the irrigated dumps in the river banks, no new dumps had been discovered.

The investigated dumps are partly served by the SPCC and partly informal. In case of the SPCC, only the non-burnable dumps are investigated. These are the dumps which contain the hazardous waste fraction.

Basis for taking the minimum sampling size is the following statistical formula:

$$Mss = \frac{1}{6}\pi * (D95)^3 * \rho * g * \frac{(1-p)}{CV^2 * p}$$

Mss Minimum Sampling Size (g)

$D95$ “Biggest particle” (95-Percentil) (cm)

ρ Particle density (g/cm³)

g Factor of particle size distribution

p m/m part of particle with determined characteristics

CV^2 strived coefficient of variation

This formula secures that all parts of a sampling size have the same chance of being represented within the sampling size (Standardization, 2006).

During the field trip the empiric used formula (Iordanopoulos-Kisser, 2013) is applied:

*Mass (kg) = 0.06 * maximum particle size (mm)*

Based on this formula and the particle with the biggest size on each dump, the sampling size for dumps had been calculated.

Figure 3: Tools used for sorting analysis on dumps and at incinerators; (Own figure)

The sorting analysis itself is conducted similar to the incinerators. After the calculated sampling size was extracted, the sorting analysis into the fractions was performed:

- Plastic
- Paper/Cardboard
- Metal
- Glass
- Residues
- Hazardous waste

Each fraction was sorted into a bag and weighted, after the sorting and weighting process, the waste was returned to the dump.

In total 13 dump samplings were conducted with an average sampling size of 10.3 kg. The total sampling size was 133.4 kg. At the dumps, a hazardous waste share of 6% was detected.

Figure 4: Non-burnable waste dump in Namche Bazar, served by the SPCC; (Own figure)

Figure 5: Informal waste dump in Phakding; (Own figure)

A declaration for the high value of hazardous waste had to be searched at the dumps of Namche Bazar. While the most of the investigated dumps show a hazardous waste fraction of 1 % to 2 %, the dumps in Namche Bazar have a comparable high hazardous waste fraction with an average of 18% on four non-burnable waste dumps, mainly due empty or nearly empty gas cartridges discarded by mountain expeditions. The cross checks with three the dumps in Kumhjung, above Namche Bazar, were showing a share of hazardous waste of approximately 2 %.

Figure 6: Non-burnable waste dump served by the SPCC with a high share of empty gas cartridges in Namche Bazar; (Own figure)

Leachate production on dumps

Leachate describes possible effects from open dumped hazardous waste in an appropriate way. It reflects the current treatment for HW in the SNPBZ and illustrates as an indicator the potential hazard to environment and health for the designed scenarios. The dumped non-burnable waste has no or nearly no organic matter in its waste body. The reaction with surrounding environment takes place via atmospheric influences.

The definition of leachate is declared as: "A liquid that has percolated through and/or been generated by decomposition of waste material. It includes water that comes into contact with waste and is potentially contaminated by nutrients, metals, salts and other soluble or suspended components and products of decomposition of the waste". (EPA, 2009)

The SPCC separates its collected waste into the burnable and non-burnable fractions. The burnable waste fraction is incinerated and dumped, while the non-burnable, hazardous waste fraction is directly dumped. Through the average high particle size of metal and glass on the non-burnable waste dumped and the specific composition out of plastic, paper and residues, a small share of humidity respectively precipitation absorbing layers within waste body is intended. 80% of the annually precipitation falls in the SNPBZ in monsoon season between June and September. (UNEP, 2008) Infiltrating water in the dumps percolates unhampered through the waste body and enables to mobilize soluble contaminants and their entry into the circumfluent soil and water bodies.

This calculation constitutes only batteries and no other contaminants from other hazardous waste items. Batteries have a high share on the hazardous waste fraction and bear the most soluble toxic contaminants.

The calculated leachate production is based on the factors:

- Average annual dumped non-burnable waste fraction
- Investigated hazardous waste share on dumps

Per kg dumped non-burnable waste 0,8 litre leachate are produced. (Karnchanawong and Limpiteeprakan, 2009)

Annual leachate production:

$$\mathrm{Leachate(a)} = \mathrm{W_{non\ burnable}\ (a)}*0{,}8$$

$\mathrm{Leachate(a)}$	Annual leachate production
$\mathrm{W_{non\ burnable}\ (a)}$	Annual dumped non-burnable waste
$0{,}8$	Leachate produced per kg dumped non-burnable waste

Based on this formula, the leachate for the years 2003 to 2013 have been calculated.

Calculated heavy metals are:

Table 5: Soluble heavy metals, the values per kg dry waste (WHO, 2008) (Own table)

Heavy Metal	Soluble share (mg/kg dry waste/a)
Mercury (Hg)	0.01
Cadmium (Cd)	0.01
Manganese (Mn)	2.76
Nickel (Ni)	0.12
Lead (Pb)	0.01
Zinc (Zn)	5.74

Annual heavy metal discharge:

$$Discharge(a) = W_{non\ burnable}(a) * HM$$

$Discharge(a)$	Annual discharged heavy metal
$W_{non\ burnable}(a)$	Annual dumped non-burnable waste
HM	Soluble heavy metal

Out of the formulas for leachate and heavy metals, the average leachate with the average total heavy metal discharge is calculated.

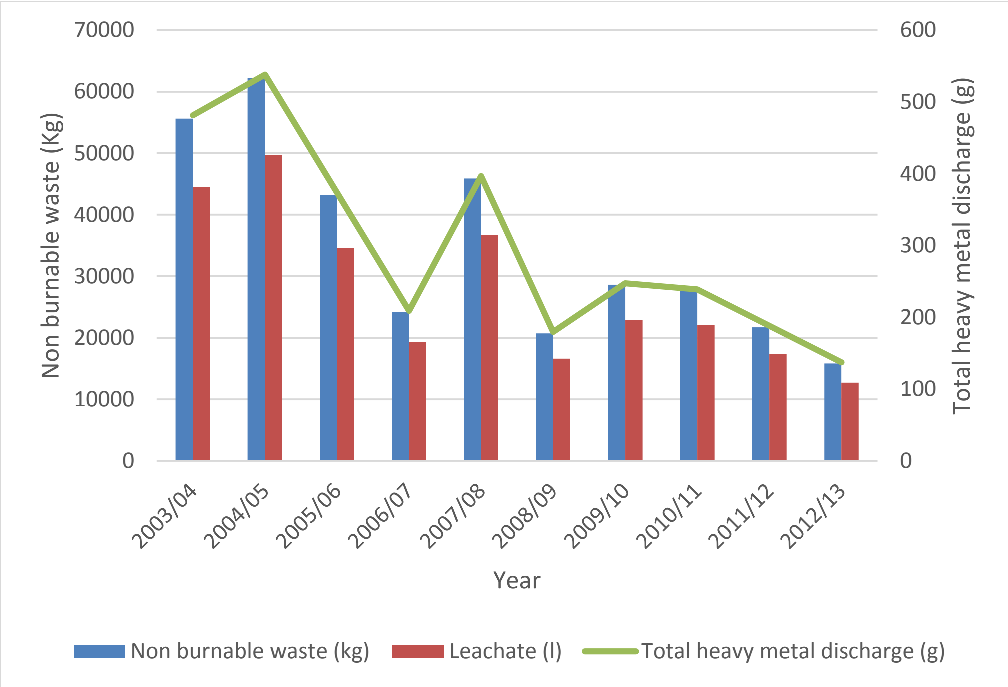


Figure 7: Seasonal leachate and total heavy metal discharge; (Karnchanawong and Limpiteeprakan, 2009) (Own figure)

The average annual quantity for non-burnable waste is 35,000 kilogram, which leads to 30,000 litre of leachate and cumulated 300 gram of soluble heavy metals which are washed out of the dumps into the environment of the SNPBZ.

Dilution for produced leachate

To remove the leachate, the demand of freshwater is calculated. It is assumed that the calculated heavy metals discharge is emitted into the groundwater which is used as a drinking water source. The threshold values are taken from the WHO drinking water standards.

Table 6: Threshold values for drinking water (WHO, 2008)

Heavy Metal	WHO drinking water threshold values (mg/l)
Mercury (Hg)	0.006
Cadmium (Cd)	0.003
Manganese (Mn)	0.4
Nickel (Ni)	0.07
Lead (Pb)	0.01
Zinc (Zn)	3

Annual demand for dilution

$$Dilution\ (a) = \frac{Discharge\ heavy\ metal}{WHO\ treshold\ value}$$

$Dilution\ (a)$ Annual demanded dilution for solved heavy metal

$Discharge\ heavy\ metal$ Annual discharged heavy metal

$WHO\ treshold\ value$ WHO threshold values for drinking water

Table 7: Annual demanded average dilution for average solved heavy metal into groundwater (Own table)

Heavy Metal	Dilution (l/mg discharged heavy metal)
Mercury (Hg)	576
Cadmium (Cd)	1,152
Manganese (Mn)	658,030
Nickel (Ni)	7,108
Lead (Pb)	3,46
Zinc (Zn)	379,481
Total demanded dilution	1,046,693

To provide the WHO-recommended drinking standards it is imperative to dilute the leachate with the usage of water. In the end of a season, approximately 1,000 m³ (1,046,693 litres) of fresh water is needed to dilute the produced leachate from the SPCC served dumps for non-burnable waste. This quantity of fresh water represents three times the yearly, average water withdrawal per inhabitant in Nepal. (FAO, 2014)

Excluded in this calculation are leachates from the SPCC served burnable waste dumps and dumps which are used by inhabitants.

Calculation waste management

The financial situation in the SNPBZ is supported mainly by the revenue of the "Khumbu Icefall Project" and waste fees. Expenditures are not broken down to individual cost positions by the SPCC. (Shahi and Shrestha, 2013)

Table 8: Financial calculations for "Scenario 0: Business as usual scenario" (Shahi and Shrestha, 2013)

Year	Revenues (Rs)	Expenditures (Rs)
2008/2009	544,310	1,350,171
2009/2010	440,159	3,140,224
2010/2011	488,055	3,267,203
Average	490,841	2,585,866

The annual expenditure of approximately 2,600,000 Rs (26,000 $) isspent for the current solid waste management in the SNPBZ with the following positions:

- Street sweeping
- Waste collection
- Waste treatment
- Waste disposal

Within the current solid waste management, hazardous waste is co-treated. The annual total costs for the "Scenario: Business as usual" are 2,600,000 Rs (26,200 $).

Calculation waste fee

The waste fee is paid by the major waste producers in the SNPBZ.

$$SPCC_{cov}(Residence) = \left(\frac{W_{col}(SPCC) - W_{pot}(Visitor)}{W_{pot}(Residence)}\right) * 100$$

$SPCC_{cov}(Residence)$	SPCC serviced covered residence
$W_{col}(SPCC)$	Waste collected by the SPCC
$W_{pot}(Visitor)$	Waste potential from visitor
$W_{pot}(Residence)$	Waste potential from residence

The SPCC covers the whole produced waste from visitors and 50% of the produced waste from residents.

The waste fee calculations are demonstrating the height of a potential waste fee for residence.

$$Wastefee(Scenario\ 0) = \frac{Cost_{Scenario\ 0}(a)}{SPCC_{cov} * SPCC_{cov}(Residence)}$$

$Wastefee(Scenario\ 0)$	Waste fee for Scenario 0
$Cost_{Scenario\ 0}(a)$	Annual cost for waste management in Scenario 0
$SPCC_{cov}$	SPCC waste service coverage
$SPCC_{cov}(Residence)$	SPCC serviced covered residence

The annual expenditures for the current applied waste management are covered, if 3,645 residence are paying 79 Rs (0.78 $) for nine months a year.

2.2.4 **Material flow analysis**

The material flow analysis (MFA) is a system defined by matter and time which shows flows and stocks. Through this flow analysis it is possible to visualize pathways of hazardous waste form its sources and shows it in a clearly laid out illustration. The MFA demonstrates different scenarios of disposal for the hazardous waste in the Sagarmatha National Park and Buffer Zone.

The main advantages of the MFA are:

- An illustration of flows and stocks in a defined system

- Identification of weak points, in which unwanted losses of hazardous waste are possible
- Basis for a deeper knowledge for key issues related to hazardous waste flows
- Background for evaluation of different scenarios. (Brunner and Rechberger, 2004)

2.2.5 **Scenario design**

The scenario design approaches different hazardous waste management possibilities. The basis scenario is the currently applied solid waste management which contains the hazardous waste. The three following scenarios are designed with additional or subtraction of processes. The changed processes are in the collection, treatment and disposal parts of the current solid waste management.

The scenarios are designed under the influence of the:

(1) Nepalese waste hierarchy
(2) Possible treatment ways in Nepal
(3) Financial restrictions

Ad (1): The Nepalese waste hierarchy is departed into the steps of:

- Reuse
- Reduction
- Recycle

Ad (2): If there are suitable treatment or disposal facilities in Nepal, the scenarios are designed in achieving the shortest transport ways.

Ad (3): The financial restrictions at play in a low-income country like Nepal cause serious restrictions. All scenarios are adapted to the local conditions and possibilities. Expenditures are unavoidable by implementing new or different waste management scenarios. Costs are compiled by keeping the current waste management up with implementing a supplement hazardous waste management. This hazardous waste management has the cost drivers of installing a HW collection scheme, constructing a central HW storage and the export out of SNPBZ to Kathmandu. The calculated waste fee, gives an example of what costs are directed to the inhabitants who are in touch with the tourism sector. As no informal sector is active within the SNPBZ, the future HW systems are not destroying any income sources. Indirect social indicators, such as health care costs are not taken into account since there are no recordings on health care expenditures in the SNPBZ.

2.2.6 Calculations "Scenario 1: Collection and long-term storage with export by trucks"

These scenarios implement hazardous waste collection systems with storage that has an uptake for five years' worth of hazardous waste. The scenario is projected with five years until the road connection to Lukla is constructed and passable. The hazardous waste storing centre is situated in Lukla.

After five years of collecting and storing hazardous waste, depending on a road connection, the export from Lukla to Kathmandu is possible.

Calculation collection

No new expenditures to the current scenario are occurring for the collection. The collection or delivering of hazardous waste is implemented in the existing collection system for solid waste. Calculated over five years, about 11,000 kg of hazardous waste was collected.

Calculations hazardous waste storing centre

The demanded volume for the future collection centre is derived out of the existing dumps. In Lukla, a dump volume of approximately 2,600 ft³ (75 m³) of volume is filled up with non-burnable waste a year.

$$Vol(HW) = 2{,}600 * hw_{Dump} * Dur_{storing}(a)$$

$Vol(HW)$	Volume of hazardous waste
$2{,}600$	Annual filled volume of one non-burnable waste dump in the SNPBZ in m³
hw_{Dump}	Share of hazardous waste on dumps
$Dur_{storing}(a)$	Duration of storing hazardous waste in years

The hazardous waste fraction occupies 6% of the total dumped waste with 156 ft³ (4.4 m³) per year. The demanded volume for storing the quantity of hazardous waste for five years is a minimum of approximately 800 ft³ (22.6 m³). As in this calculated 800 ft³, the hazardous waste from Namche Bazar is excluded, the storing centre will be calculated for the doubled volume of 1,600 ft³ (45.3 m³).

The hazardous waste storing centre is divided into four compartments for the main hazardous waste (Batteries, Compact fluorescent light bulbs, Medical supplies, gas cartridges) types. The costs for construction are about 2,900 Rs (29 \$) per ft². (Dhungana, 2013)

$$Cost_{Storing\ Centre} = Area_{Storing\ Centre} * Cost_{Construction}$$

$Cost_{Storing\ Centre}$ Costs for constructing storing centre with four compartments

$Area_{Storing\ Centre}$ Area of storing centre

$Cost_{Construction}$ Average costs for construction per square feet in Nepal

Table 9: Volume and total costs for hazardous waste storing centre for "Scenario 1" (Dhungana, 2013) (Own table)

	Compartment	Centre	Costs (Rs)
Area (ft²)	67	267	
Wall (ft)	6	6	
Volume (ft³)	400	1,600	773,000

The demanded volume for a hazardous waste centre is 1,600 ft³ (45 m³). The construction costs are 773,000 Rs (7,730 \$).

Calculation transport costs

Costs for transportation are composed out of 35 Rs per kg for porters (Zuser et al., 2011) in the SNPBZ and 10 Rs per kg for the truck export (Sangam, 2014) to Kathmandu.

$$Cost_{Porter} = 35 * HW(a) * Dur_{Scenario\ 1}(a)$$

$Cost_{Porter}$ Total transport costs for porters

35 Salary per kg for transporting in Nepalese Rupees

$HW(a)$ Annual quantity of hazardous waste

$Dur_{Scenario\ 1}(a)$ Duration of Scenario 1

$$Cost_{Truck} = 10 * HW(a) * Dur_{Scenario\ 1}(a)$$

$Cost_{Truck}$ Total transport costs for trucks

10 Costs per kg for transport by truck (Rs)

$HW(a)$ Annual quantity of hazardous waste

$Dur_{Scenario\ 1}(a)$ Duration of "Scenario 1"

Table 10: Total transport costs for porters and truck export for "Scenario 1"(Zuser et al., 2011) (Sangam, 2014)(Own table)

	Rs
Porter	367,500
Truck	105,000
Total	475,250

The cost for transporting the collected hazardous waste within the SNPBZ by porters is 367,500 Rs (3,675 $). These costs are covering the expenditures for five years the transporting of the hazardous waste from Namche Bazar to Lukla and the unloading of the hazardous waste storing centre. The truck export from the hazardous waste collection centre in Lukla to Namche Bazar is 105,000 Rs (1,050 $). In total about 475,250 Rs (4,752 $) is demanded for transportation and exporting the hazardous waste in the SNPBZ to Lukla and further to Kathmandu.

Calculation staff cost

In order to provide a service regarding collection, sorting and maintaining the collection centre, one working place is established for at least five months during the high touristic seasons. The average Nepalese salary is 3,400 Rs (34$) per month. (Statistics, 2008)

$$Cost_{Staff} = Salary * Dur_{Employment}(m/a) * \ Dur_{Scenario\ 1}(a)$$

$Cost_{Staff}(a)$ Annual staff costs

$Salary$ Average nepalese salary per month

$Dur_{Employment}(m/a)$ Annual duration of employment in months

$Dur_{Scenario\ 1}(a)$ Duration of Scenario 1

Calculated over five years the total salary for one workplace is 85,000 Rs (850$), which makes an annual salary of 17,000 Rs (170$) for five months occupation.

Calculation total scenario cost

Table 11: Total cost assumption for "Scenario 1"

Year	1	2	3	4	5	Total (Rs)
Construction	773,000					773,000
Transport Porters	73,500	73,500	73,500	73,500	73,500	367,500
Transport Truck					105000	107,750
Staff	17,000	17,000	17,000	17,000	17,000	85,000

Total	863,500	90,500	90,500	90,500	195,500	1,330,500
Average	266,100	266,100	266,100	266,100	266,100	

The annual costs for “Scenario 1: Collection and long-term storage with export by trucks”, is 266,100 Rs (2,661 $). Within in these costs are the collection, storing and the export of hazardous waste to Kathmandu. The cumulated costs for managing 10,500 kg of hazardous waste over five years is approximately 1,330,500 Rs (13,305 $).

Calculation waste fee

Hazardous waste fee for „Scenario 1”:

$$Wastefee(Scenario\ 1) = \frac{Cost_{Scenario\ 1}(a)}{SPCC_{cov} * SPCC_{cov}(Residence)}$$

$Wastefee(Scenario\ 1)$	Waste fee for “Scenario 1”
$Cost_{Scenario\ 1}(a)$	Annual cost for hazardous waste management in “Scenario 1”
$SPCC_{cov}$	SPCC waste service coverage
$SPCC_{cov}(Residence)$	SPCC serviced covered residence

Cumulated waste fee for “Scenario 1”:

$$Cum.wastefee(Scenario\ 1) = \left(\frac{Cost_{Scenario\ 0}(a)}{SPCC_{cov} * SPCC_{cov}(Residence)}\right) + \left(\frac{Cost_{Scenario\ 1}(a)}{SPCC_{cov} * SPCC_{cov}(Residence)}\right)$$

$Cum.wastefee(Scenario\ 1)$	Cumulated waste fee for “Scenario 1”
$Cost_{Scenario\ 0}(a)$	Annual cost for waste management in “Scenario 0”
$Cost_{Scenario\ 1}(a)$	Annual cost for waste management in Scenario 1
$SPCC_{cov}$	SPCC waste service coverage
$SPCC_{cov}(Residence)$	SPCC serviced covered residence

The fee for servicing the annual generated 2,100 kg of hazardous waste is 8 Rs (0.08$) for one resident per month per year. The accumulated waste fee of 87 Rs (0.87$) per capita, month and year, is composed out of 79 Rs (0.79$) for the solid waste management in "Scenario 0" and the additional 8 Rs (0.08$) for the designed hazardous waste management in "Scenario 1".

2.2.7 Calculations "Scenario 2: Collection, storage and annual export by plane"

This scenario is for a hazardous waste collection system with a storage uptake for one year of hazardous waste collection. The scenario is projected for one year and the annual export of hazardous waste to Kathmandu. The hazardous waste storing centre is situated in Lukla.

Calculation collection

No new expenditures to the current scenario are occurring for the collection. The collection or delivering of hazardous waste is implemented in the existing collection system for solid waste. Calculated over one year about 2,100 kg of hazardous waste are collected.

Calculations hazardous waste storing centre

The demanded volume for the collection centre is derived out of the existing dumps. In Lukla, a dump volume of approximately 2,600 ft³ (75 m³) of volume is filled up with non-burnable waste a year. The hazardous waste fraction occupies 6% of the total dumped waste with 156 ft³ (4.4 m³) per year.

$$Vol(HW) = 2{,}600 * hw_{Dump} * Dur_{storing}(a)$$

$Vol(HW)$	Volume of hazardous waste
$2{,}600$	Annual filled volume of one non-burnable waste dump in the SNPBZ in m³
hw_{Dump}	Share of hazardous waste on dumps
$Dur_{storing}(a)$	Duration of storing hazardous waste in years

The demanded minimum volume for storing the quantity of hazardous waste for one year is approximately 160 ft³ (4.5 m³). As in this calculated 160 ft³, the hazardous waste from Namche Bazar is excluded, the storing centre will be calculated for the doubled volume of 320 ft³ (9 m³).

The hazardous waste storing centre is divided into four compartments for the main hazardous waste (Batteries, Compact fluorescent light bulbs, Medical supplies, gas cartridges) types. The costs for construction are 2,900 Rs (29 $) per ft². (Dhungana, 2013)

$$Cost_{Storing\ Centre} = Area_{Storing\ Centre} * Cost_{Construction}$$

$Cost_{Storing\ Centre}$	Costs for constructing storing centre with four compartments
$Area_{Storing\ Centre}$	Area of storing centre
$Cost_{Construction}$	Average costs for construction per square feet in Nepal

Table 12: Volume and total costs for hazardous waste storing centre for "Scenario 2" (Dhungana, 2013) (Own table)

	Compartment	Centre	Cost (Rs)
Area (ft²) Wall (ft)	13 6	53 6	
Volume (ft³)	80	320	155,000

The construction costs for the demanded minimum volume of 320 ft³ (9 m³) are approximately 155,000 Rs (1,550 $).

Calculation transport costs

Costs for transportation are composed out of 35 Rs (0,35 $)per kg for porters (Zuser et al., 2011) in the SNPBZ and 65 Rs (0.65 $) per kg for the plane export (Zuser et al., 2011) to Kathmandu.

$$Cost_{Porter} = 35 * HW(a) * Dur_{Scenario\ 2}(a)$$

$Cost_{Porter}$	Total transport costs for porters
35	Salary per kg for transporting in Nepalese Rupees
$HW(a)$	Annual quantity of hazardous waste
$Dur_{Scenario\ 2}(a)$	Duration of "Scenario 2"

$$Cost_{Plane} = 65 * HW(a) * Dur_{Scenario\ 1}(a)$$

$Cost_{Truck}$	Total transport costs for trucks
65	Cost per kg for transport by plane (Rs)
$HW(a)$	Annual quantity of hazardous waste

$$Dur_{Scenario\ 1}(a) \qquad \text{Duration of “Scenario 1”}$$

Table 13: Total transport costs for porters and truck export for “Scenario 2” (Zuser et al., 2011) (Sangam, 2014) (Own table)

	Rs
Porter Airplane	367,500 682,500
Total	1,050,000

The annual cost for transporting the collected hazardous waste within the SNPBZ by porters is 73,500 Rs (735 \$). These costs are for transporting the hazardous waste from Namche Bazar to Lukla and to unload the hazardous waste storing centre. The annual airplane export from the hazardous waste collection centre in Lukla to Namche Bazar is 136,500 Rs (1,365 \$). Annually 210,000 Rs (2,200 \$) are demanded per year for flying and exporting the hazardous waste in the SNPBZ to Lukla and further to Kathmandu. Cumulated over five the cost will increase to 1,050,000 Rs (10,500 \$).

Calculation staff cost

$$Cost_{Staff} = Salary * Dur_{Employment}(m/a) * Dur_{Scenario\ 2}(a)$$

$Cost_{Staff}(a)$	Annual staff costs
$Salary$	Average Nepalese salary per month
$Dur_{Employment}(m/a)$	Annual duration of employment in months
$Dur_{Scenario\ 2}(a)$	Duration of “Scenario 2”

In order to provide a service regarding collection, sorting and maintaining the collection centre, one working place is established for at least five months during the high touristic seasons. The average Nepalese salary is 3,400 Rs (34\$) per month. (Statistics, 2008) The annual staff costs are 17,000 Rs (170 \$) and cumulated over five years 85,500 Rs (855 \$).

Calculation total scenario cost

Table 14: Total cost assumption for "Scenario 2" (Own table)

Year	1	2	3	4	5	Total (Rs)
Construction Transport Porters Transport Airplane Staff	155,000 73,500 136,500 17,000	 73,500 136,500 17,000	 73,500 136,500 17,000	 73,500 136,500 17,000	 73,500 136,500 17,000	155,000 367,500 682,500 85,000
Total	382,000	227,000	227,000	22,7000	227,000	1,290,000
Average	258,000	258,000	258,000	258,000	258,000	

The annual cost for “Scenario 2: Collection, storage and annual export by plane”, is 258,000 Rs (2,580 \$). Within in these costs are the collection, storing and the annual export of hazardous waste by plane to Kathmandu. The cumulated cost for 2,100 kg of hazardous waste over five years is approximately 1,290,000 Rs (12,900 $).

Calculation waste fee

Hazardous waste fee for „Scenario 2":

$$Wastefee(Scenario\ 2) = \frac{Cost_{Scenario\ 2}(a)}{SPCC_{cov} * SPCC_{cov}(Residence)}$$

$Hazardou\ waste\ fee(Scenario\ 2)$	Waste fee for "Scenario 2"
$Cost_{Scenario\ 2}(a)$	Annual cost for hazardous waste management in "Scenario 2"
$SPCC_{cov}$	SPCC waste service coverage
$SPCC_{cov}(Residence)$	SPCC serviced covered residence

Cumulated waste fee for "Scenario 2":

$$Cum.wastefee(Scenario\ 2) = \left(\frac{Cost_{Scenario\ 0}(a)}{SPCC_{cov} * SPCC_{cov}(Residence)}\right) + \left(\frac{Cost_{Scenario\ 2}(a)}{SPCC_{cov} * SPCC_{cov}(Residence)}\right)$$

$Cum.wastefee(Scenario\ 2)$	Cumulated waste fee for "Scenario 2"
$Cost_{Scenario\ 0}(a)$	Annual cost for waste management in "Scenario 0"
$Cost_{Scenario\ 2}(a)$	Annual cost for waste management in "Scenario 2"
$SPCC_{cov}$	SPCC waste service coverage
$SPCC_{cov}(Residence)$	SPCC serviced covered residence

The hazardous waste fee for servicing the annual generated 2,100 kg of hazardous waste is 8 Rs (0,08 $) for one resident per month and year. The total waste fee of 87 Rs (0.87$) per capita, month and year is composed out of 79 Rs (0.79$) for the solid waste management in "Scenario 0" and the additional 8 Rs (0.08$) for the designed hazardous waste management in "Scenario 2".

2.2.8 Calculations “Scenario 3: Road connection to Lukla under the perspective of hazardous waste “

The third scenario enlightens the future consequences of the changes, if Lukla is connected to a tarmac road. Residents number 7,161 people, (STATISTICS, 2011a) this includes, permanent residents within the SNPBZ for 275 days, with 90 days of absence in the winter season. The waste production from residents has risen from 0.155 kg/day/capita to the Nepalese average of 0.376 kg/day/capita. The number of visitors is 25,520 (RAI, 2014) per year which are staying 10 days (MANFREDI et al., 2010). Each visitor produces 0.204 kg/d/capita.

The hazardous waste collection system with a storage volume for the one year quantity of hazardous waste is situated in Lukla. The export of hazardous waste to Kathmandu would be done annually.

Average Nepalese waste production

The average national waste production is an averaged value of 376 grams per capita and year.

Table 15: Calculations on national wide average waste production (Own table)

Source	Waste generation (kg/cap/d)
(Mishra and Kayastha, 1998)	0.565
(Reconstruction and Development, 1999)	0.5
(Practical Action, 2008)	0.5
(Pokhrel and Viraraghavan, 2005)	0.25
(ADB, 2013)	0.317
Average	0.376

Calculation on future waste potential

$$W_{pot}(a)_{(Visitor)} = W_{prod}(Visitor) * \emptyset\ Visitor_{(a)} * \emptyset\ Sojourn\ (Visitor)$$

$Wpot(a)_{(Visitor)}$	Annual waste potential, Visitors
$W_{prod}(Visitor)$	Daily waste production, Visitor
$\emptyset\ Visitor_{(a)}$	Average annual number of visitors
$\emptyset\ Sojourn\ (Visitor)$	Average staying, Visitor

$$Wpot(a)(_{Residence}) = W_{prod}(Residence) * Residence(a) * \emptyset\ Sojourm\ (Residence)$$

$W_{pot}(a)(Residence)$	Annual waste potential, Residence
$W_{prod}(Residence)$	Daily waste production, Residence
$Residence(a)$	Residence living permanent in the SNPBZ
$\emptyset\ Sojourm\ (Residence)$	Average staying, Residence

$$W_{pot}(Total) = W_{pot}(a)_{(Visitor)} + W_{pot}(a)(_{Residence})$$

$W_{pot}(Total)$	Total waste potential
$W_{pot}(a)_{(Visitor)}$	Annual waste potential, Visitors
$W_{pot}(a)(Residence)$	Annual waste potential, Residence

$$\mathrm{W}_{\text{non burnable}}\ (\mathrm{a}) = W_{pot}(Total) * \mathrm{nb}_{Waste}$$

$\mathrm{W}_{\text{non burnable}}\ (\mathrm{a})$	Annual dumped non-burnable waste
$W_{pot}(Total)$	Total waste potential
nb_{Waste}	Non-burnable waste share

$$HW(a) = W_{pot}(Total) * hw_{Incinerator}$$

$HW(a)$	Annual hazardous waste quantity
$W_{pot}(Total)$	Total waste potential
$hw_{Incinerator}$	Hazardous waste share at incinerator

$$SPCC_{cov} = \left(\frac{W_{col}(SPCC)}{W_{pot}(Total)}\right) * 100$$

$SPCC_{cov}$	SPCC waste service coverage
$W_{col}(SPCC)$	Collected waste from the SPCC as in "Scenario 0"
$W_{pot}(Total)$	Total waste potential as in "Scenario 3"

Table 16: Future waste potential and hazardous waste in the SNPBZ for "Scenario 3" (Own table)

	Visitors	Residence
Waste production (kg/cap/d)	0.204	0.376
Waste potential (kg/a)	52,061	741,235
Total waste potential (kg/a)	793,296	
Non burnable waste fraction (kg/a)	126,927	
Future hazardous waste (kg)	8,330	
SPCC waste service coverage (%)	26	

The future waste potential is approximately 790,000 kg. The SPCC service coverage on produced waste decreases from 60% to approximately 30%. According to these calculations 70% of the produced waste would be unmanaged. The waste composition stays the same as in the current status. The annual hazardous waste quantity rises from 2,100 kg to 8,330 kg.

Calculation leachate

The calculated leachate production is based on the factors:

- Quantity of dumped non-burnable waste fraction
- Investigated hazardous waste share on dumps

Per kg dumped non-burnable waste 0,8 litre leachate is produced. (Karnchanawong and Limpiteeprakan, 2009)

Annual leachate production:

$$\mathrm{Leachate(a)} = \mathrm{W}_{\mathrm{non\ burnable}}\ \mathrm{(a)}*0{,}8$$

$\mathrm{Leachate(a)}$	Annual leachate production
$\mathrm{W}_{\mathrm{non\ burnable}}\ \mathrm{(a)}$	Annual dumped non-burnable waste
$0{,}8$	Leachate produced per kg dumped non-burnable waste

Based on this formula, the leachate for the years 2003 to 2013 are calculated.

Calculated heavy metals are:

Table 17: Soluble heavy metals, the values per kg dry waste (Karnchanawong and Limpiteeprakan, 2009) (Own table)

Heavy Metal	Soluble share (mg/kg dry waste/a)
Mercury (Hg)	0.01
Cadmium (Cd)	0.01
Manganese (Mn)	2.76
Nickel (Ni)	0.12
Lead (Pb)	0.01
Zinc (Zn)	5,74

Annual heavy metal discharge:

$$Discharge(a) = W_{non\ burnable}(a) * HM$$

$Discharge(a)$	Annual discharged heavy metal
$W_{non\ burnable}(a)$	Annual dumped non-burnable waste
HM	Soluble heavy metal

The average annual quantity on non-burnable waste is 126,927 kilogram, which leads to 101,542 litre of leachate and accumulated 1.097 gram of soluble heavy metals which are washed out of the dumps into the environment of the SNPBZ.

Dilution for produced leachate

To defang the leachate the demand of freshwater is calculated. It is assumed that the calculated heavy metals discharge is emitted into the groundwater which is used as drinking water source. The threshold values are taken from the WHO drinking water standards.

Table 18: Threshold values for drinking water (WHO, 2008)

Heavy Metal	WHO drinking water threshold values (mg/l)
Mercury (Hg)	0.006
Cadmium (Cd)	0.003
Manganese (Mn)	0.4
Nickel (Ni)	0.07
Lead (Pb)	0.01
Zinc (Zn)	3

Annual demand for dilution

$$Dilution\ (a) = \frac{Discharge\ heavy\ metal}{WHO\ treshold\ value}$$

$Dilution\ (a)$	Annual demanded dilution for solved heavy metal
$Discharge\ heavy\ metal$	Annual discharged heavy metal
$WHO\ treshold\ value$	WHO threshold values for drinking water

Table 19: Annual demanded average dilution for average solved heavy metal into groundwater (Karnchanawong and Limpiteeprakan, 2009) (Own table)

Heavy Metal	Dilution (l/mg discharged heavy metal)
Mercury (Hg)	2,115
Cadmium (Cd)	4,231
Manganese (Mn)	2,417,205
Nickel (Ni)	26,111
Lead (Pb)	1,269
Zinc (Zn)	1,393,984
Total demanded dilution	3,844,915

To provide the WHO-recommended drinking standards it is indispensable to dilute the leachate as far as a harmless usage of water is ensured. At the end of a season, approximately 4,000 m³ (3,844,915 litres) of fresh water is needed to dilute the produced leachate from the SPCC served dumps for non-burnable waste. This quantity of fresh water represents three times the yearly, average water withdrawal per inhabitant in Nepal. (FAO, 2014) Excluded in this calculation are leachates from the SPCC served burnable waste dumps and dumps which are used by inhabitants.

Calculation collection

No expenditures to the current scenario are implemented for the collection. The collection or delivering of hazardous waste is implemented in the existing collection system for solid waste.

Calculations hazardous waste storing centre

The demanded volume of the future collection centre is derived out of the existing dumps. In Lukla, a dump volume of approximately 2,600 ft³ (75 m³) of volume is filled up with non-burnable waste a year. The hazardous waste fraction occupies 6% of the total dumped waste with 156 ft³ (4.4 m³) per year. The quantity of 8,330 kg hazardous waste is equal to the quantity of four times 2,100 kg hazardous waste from previous scenarios. For that reason the duration for storing hazardous waste is counted with four years instead although it is emptied annually.

$$Vol(HW) = 2{,}600 * hw_{Dump} * Dur_{storing}(a)$$

$Vol(HW)$	Volume of hazardous waste

$2{,}600$	Annual filled volume of one non-burnable waste dump in the SNPBZ in m³
hw_{Dump}	Share of hazardous waste on dumps
$Dur_{storing}(a)$	Duration of storing hazardous waste in years

The demanded volume for storing the quantity of hazardous waste for one is the equal volume of four years from the previous scenarios, with a minimum size of 624 ft³ (17,7 m³). As in this calculated 624 ft³, the hazardous waste from Namche Bazar is excluded, the storing centre will be calculated for the doubled volume of approximately 1,248 ft³ (36,8 m³).

The hazardous waste storing centre is divided into four compartments for main hazardous waste (Batteries, Compact fluorescent light bulbs, Medical supplies, gas cartridges) types. The costs for construction are about 2,900 Rs (29 $) per ft². (Dhungana, 2013)

$$Cost_{Storing\ Centre} = Area_{Storing\ Centre} * Cost_{Construction}$$

$Cost_{Storing\ Centre}$	Costs for constructing storing centre with four compartments
$Area_{Storing\ Centre}$	Area of storing centre
$Cost_{Construction}$	Average costs for construction per square feet in Nepal

Table 20: Volume and total costs for hazardous waste storing centre for “Scenario 3” (Dhungana, 2013) (Own table)

	Compartment	Centre	Costs (Rs)
Area (ft²) Wall (ft)	52 6	208 6	
Volume (ft³)	312	1248	598,000

The demanded volume for a hazardous waste centre is 1,248 ft³ (36.8 m³). The construction cost is 598,000 Rs (5,980 $).

Calculation transport costs

Costs for transportation are composed of 35 Rs (0.35$) per kg for porters (Zuser et al., 2011) in the SNPBZ and 10 Rs (0.1$) per kg for the truck export (Sangam, 2014) to Kathmandu.

$$Cost_{Porter} = 35 * HW(a) * Dur_{Scenario\ 3}(a)$$

$Cost_{Porter}$	Total transport costs for porters
35	Salary per kg for transporting in Nepalese Rupees
$HW(a)$	Annual quantity of hazardous waste
$Dur_{Scenario\ 1}(a)$	Duration of “Scenario 1”

$$Cost_{Truck} = 10 * HW(a) * Dur_{Scenario\ 1}(a)$$

$Cost_{Truck}$	Total transport costs for trucks
10	Costs per kg for transport by truck (Rs)
$HW(a)$	Annual quantity of hazardous waste
$Dur_{Scenario\ 1}(a)$	Duration of “Scenario 1” in years

Table 21: Transport costs porters and truck export for “Scenario 3” (Zuser et al., 2011) (Sangam, 2014) (Own table)

	Rs
Porter	1,457,750
Truck	416,500
Total	1,874,250

The annual cost for transporting the collected hazardous waste within the SNPBZ by porters is 291,550 Rs (2,915 $), these costs are for transporting the hazardous waste from Namche Bazar to Lukla and to unload the hazardous waste storing centre. The annual truck export from the hazardous waste collection centre in Lukla to Namche Bazar is 83,300 Rs (830 $). Over five years, 1,874,250 Rs (18,742 $) is demanded for transportation the hazardous waste in the SNPBZ to Lukla and the export to Kathmandu.

Calculation staff cost

$$Cost_{Staff} = Salary * Dur_{Employment}(m/a) * \ Dur_{Scenario\ 3}(a)$$

$Cost_{Staff}(a)$	Annual staff costs
$Salary$	Average Nepalese salary per month
$Dur_{Employment}(m/a)$	Annual duration of employment in months
$Dur_{Scenario\ 3}(a)$	Duration of “Scenario 3”

In order to provide a service regarding collection, sorting and maintaining the collection centre one working place is established for at least five months during the high tourist seasons. The average Nepalese salary is 3,400 Rs (34$) per month. (Statistics, 2008) The annual staff costs are 17,000 Rs (170 $) and accumulated over five years 85,500 Rs (855 $).

Calculation total scenario cost

Table 22: Total cost assumption for "Scenario 3: Road connection to Lukla under the perspective of hazardous waste" (Own table)

Year	1	2	3	4	5	Total (Rs)
Construction	598,000					598,000
Transport Porters	291,550	291,550	291,550	291,550	291,550	1,457,750
Transport Truck	83,300	83,300	83,300	83,300	83,300	416,500
Staff	17,000	17,000	17,000	17,000	17,000	85,000
Total	989,850	391,850	391,850	391,850	391,850	2,557,250
Average	511,450	511,450	511,450	511,450	511,450	

The annual costs for “Scenario 3: Road connection to Lukla under the perspective of hazardous waste”, is 511,450 Rs (5,114 $). Within in these costs are the collection, storing and the annual export of hazardous waste by truck to Kathmandu. The accumulated cost for 8,330 kg of hazardous waste over five years is 2,257,250 Rs (22,572 $).

Calculation waste fee

Hazardous waste fee for „Scenario 3”:

$$Hazardous\ waste\ fee(Scenario\ 3) = \frac{Cost_{Scenario\ 3}(a)}{SPCC_{cov} * SPCC_{cov}(Residence)}$$

$Hazardous\ waste\ fee(Scenario\ 3)$	Waste fee for “Scenario 3”
$Cost_{Scenario\ 3}(a)$	Annual cost for hazardous waste management in “Scenario 3”

$SPCC_{cov}$ SPCC waste service coverage

$SPCC_{cov}(Residence)$ SPCC serviced covered residence

Cumulated waste fee for "Scenario 3":

$$Cum.wastefee(Scenario\ 3) = \left(\frac{Cost_{Scenario\ 0}(a)}{SPCC_{cov} * Residence_{SNPBZ}}\right) + \left(\frac{Cost_{Scenario\ 3}(a)}{SPCC_{cov} * Residence_{SNPBZ}}\right)$$

$Cum.wastefee(Scenario\ 3)$ Cumulated waste fee for "Scenario 3"

$Cost_{Scenario\ 0}(a)$ Annual cost for waste management in "Scenario 0"

$Cost_{Scenario\ 3}(a)$ Annual cost for hazardous waste management in "Scenario 3"

$SPCC_{cov}$ SPCC waste service coverage

$SPCC_{cov}(Residence)$ SPCC serviced covered residence

The fee for annual service generated 8,330 kg of hazardous waste is 16 Rs (0, 16 $) for one resident per month and year. The total waste fee of 95 Rs (0.95$) per capita, month and year is composed out of 79 Rs (0.79 $) for the solid waste management in "Scenario 0" and the additional 16 Rs (0.16 $) for the designed hazardous waste management in "Scenario 3".

2.2.9 **Assessment methodology**

Environmental assessement

The scenarios are assessed by two indicators. The first indicator is the environmental benefit, defined through collected hazardous waste and avoided leachate. Second indicator is the expected expenditures caused by the implemented hazardous waste management.

The assessment methodology was applied in order to provide a method which is able to assess multiple criteria and determine the best scenario for specific circumstances. Basis for an assessment is the defined goal in the "Nepalese Solid Waste Management Act, 2011" where the aim of solid waste management is: "…maintain the clean and healthy environment by minimizing the adverse effects of the solid waste in the public health and environment…". (MUD, 2011)

Environmental goals are assessed on the direct indicator of dumped hazardous waste and the indirect indicator of leachate production though open dumped hazardous waste in combination with general waste. The direct influence of hazardous waste is the infection of co-dumped waste. In particular, infusion bags and needles from health care establishments, the untreated dumping with general waste increases the danger of injuries or transmitting diseases for people who are in danger of coming into contact with said waste. The dumping of hazardous waste with general waste may lead also to the indirect indicator of which the assessment of the scenarios was conducted, the production of leachate.

Leachate as an indirect indicator, represents the consequences of dumping hazardous waste at open dumps. Through the unhampered access of water to dumps, the washed out contaminants have the ability to enter the runoff, transmit and contaminate water from the dumps. Contamination in the groundwater, which is used as a ground water source, constitutes the capability of harming human health. If contaminated, water that is not directly consumed remains also available through consuming agricultural products.

Greenhouse gases were not taken as indicator. Reason being, the low expressiveness regarding hazardous waste. Hazardous waste doesn’t decompose within the dump and doesn´t emit climate relevant gases, the only exception here is the remaining gas in discarded gas cartridges. In context of the treatment of the non-burnable waste, which contains the hazardous waste fraction, no greenhouse gas emitting process is included. During the export out of the SNPBZ, greenhouse gases aren´t taken as indicator, as the focus on assessing the different scenarios should remain on the effects of hazardous waste. Greenhouse gases which are produced by the export shouldn´t influence the choice of the best HW solution for the SNPBZ.

Financial assessment

The financial assessment is based on the cost for managing one kilogram of collected waste. This calculation secures a transparent comparability for the designed scenarios. Within management costs are the construction of the hazardous waste centre, the collection, transportation and exportation. Exception is “Scenario 0”, in this scenario all costs are amortised, due the lack of information no specific cost drivers are identified.

$$Waste_{cost}(Scenario\ 0) = \frac{Annual\ Cost\ (Scenario\ 0)}{Annual\ Collected\ Waste\ (Scenario\ 0)}$$

$Waste_{cost}(Scenario\ 0)$	Waste costs per kilogram for “Scenario 0”
$Annual\ Cost\ (Scenario\ 0)$	Annual total costs for managing collected solid waste
$Annual\ Collected\ Waste\ (Scenario\ 0)$	Annual collected solid waste

$$Waste_{cost}(Scenario\ 1,2,3) = \frac{Annual\ Cost\ (Scenario\ 1,2,3)}{Annual\ Collected\ Hazarodus\ waste\ (Scenario\ 1,2,3)}$$

$Waste_{cost}(Scenario\ 1,2,3)$	Waste costs per kilogram for “Scenario 1,2,3”
$Annual\ Cost\ (Scenario\ 1,2,3)$	Annual total costs for managing collected hazardous waste
$Annual\ Collected\ Waste\ (Scenario\ 1,2,3)$	Annual collected hazardous waste

3. Literature review

3.1 Comparison on waste definitions

To start from the base and to have an international understanding on what is solid waste, the official definition from the "Organisation for Economic Co-operation and Development" (OECD) on solid waste is:

"Solid waste is useless and sometimes hazardous material with low liquid content. Solid wastes include municipal garbage, industrial and commercial waste, sewage sludge, wastes resulting from agricultural and animal husbandry operations and other connected activities, demolition wastes and mining residues." (OECD, 2001)

In comparison to the definition from the OECD states the definition from the Government of Nepal from the year 1987 is shorter and defines solid waste as followed:

"Solid Waste means materials which are in a state of disuse, or which have been disposed of, or such other materials which are declared as solid waste by the Center [sic] from time to time (MUD, 1987)"

To understand the definition completely it is necessary to know the definition of the term "Center" : "…means the Solid Waste Management and Resource Mobilization Center.(MUD, 1987)

The OECD definition is specific about waste itself and defines also the source of solid waste. It includes also the industrial and commercial waste and gives a first reference in direction of hazardous waste.

The Nepalese definition relies on the local "Solid Waste Management and Resource Mobilization Center" to define what solid waste is. The definition from Nepal is more liken to the generic term of "waste" in industry countries.

3.2 Socio-economic background for waste management in Nepal

This chapter is about the socio-economical background in which the waste management from Nepal is embedded.

Two parameters are selected:

(1) Population;
(2) Gross Domestic Product (GDP).

With the population parameter, a social indicator is given and includes the underlying information about the distribution overall in Nepal and on its three different regions, the urbanisation rate and the growth rate of the Nepalese society.

In naming the GDP as economic indicator, the financial status of the national economy of Nepal is shown.

These two indicators will be combined in a final table.

Population

Nepal is located in the centre of the Himalayan belt, it has a very variable relief and is divided into three different geographic regions starting with the Terai at 60 metres above sea level going over to the hills and ending at the top at the Mount Everest at 8,848 metres above sea level.

Through over this band width of altitudes, also the population is divers distributed;

Table 23: Population size and distribution (CBS 2011) (Pokhrel and Viraraghavan, 2005) (Own table)

Region	Percentage of region on total land (%)	Regions in thousand Square kilometers (km^2)	Percentage from total population (%)	Population in Millions
Mountainous region	15	22,07	6,73	1,78
Hills	68	100	43	11,39
Terai	17	25,02	50,27	13,32
Total	100	147,09	100	26,49

Within the above table, one can see that the main share of the population is situated in the Terai, followed by the hills region and the least populated part of Nepal, the mountainous region.

The annual population growth rate is 1,2 percentage (%) per year (WORLDBANK, 2014).

Looking at the urbanisation rate, Nepal has a living population of 4, 5 Billion people in its cities; this is about 17 % of the total population. This is roughly the half of the average urbanisation rate in South Asia. (WORLDBANK, 2014) Still, the value of urbanisation is forecasted to increase during the next years by an annual rate of 7,1%. (CBS, 2011)The biggest city in Nepal, with more than one billion inhabitants, is Kathmandu. (CBS, 2011)

Economic background for waste management

In the year 2012, Nepal had a Gross Domestic Product of 18,96 Billion US Dollars ($), with a slight tendency to increase. (WORLDBANK, 2014) Which means, 1279,28 $ per capita purchasing power parity (PPP).

The major occupation is the agricultural sector as 76 % of the Nepalese households are employed in farm related activities. After agriculture, 56 % of the households are receiving remittances. Overall agriculture and tourism are the main financial income sources. (GON, 2011) The lack of political stability and the weak implementation of state policies have left the Nepalese economic beyond the average GDP of developing countries. (WORLDBANK, 2014) Waste production in comparison to Population and GDP.

Table 24: Information on GDP, waste generation and waste composition for selected south asian countries in comparison to Austria (SHEKDAR, 2009; FEDEC and SOUSA, 2014; VI/3 and UMWELTBUNDESAMT, 2011) (Own table)

Coun-try	GDP (PPP) ($/cap/a)	Waste generation (kg/cap/d)	Composition (% wet weight basis)						
			Bio-degradable	Pa-per	Plastic	Glass	Metal	Textile/ Leather	Inert and other
Hong Kong	37,339	2.25	38	26	19	3	2	3	9
Japan	33,010	1.1	26	46	9	7	8	-	12
China	8,854	0.8	35,8	3,7	3,8	2	0,3	-	47,5
Phili-ppines	5,409	0.3 – 0.7	41,6	19,5	13,8	2,5	4,8	-	17.9
Lao PDR	2,260	0.7	54,3	3,3	7,8	8,5	3,8	-	22,5
Nepal	1,760	0.2 – 0.5	80	7	2,5	3	0,5	-	7
Austria	43,085	1.3	37	11	18	5	4,6	6	18,4

Hong Kong, who has the highest GDP also, has the highest waste production per capita and day. On the other end of the table is Nepal with the lowest GDP per head with only 0,2 kg to 0,5 kg per day. With a lower GDP, the share of biodegradables are higher, also the share of plastic the lowest in all observed countries.

The main municipal expenditures are not on waste management but rather on other public services.(ADB, 2013) According to the report from the Asian development bank (2013) it is named that the municipalities in Nepal spend about 10% of their total budget on managing solid waste. Calculated on one ton of waste, municipalities spend about 2,840 Nepalese Rupees (Rs.), which is 28,40 $ for collection, transport and disposal.

Table 25: Annually municipal expenditures for waste management in Nepal (ADB, 2013) (Bank, 2013)

	Street Sweeping / Collection		Transportation		Disposal		Total
	%	Monetary	%	Monetary	%	Monetary	Monetary
Rs.	60-70	1,704-1,988	20-30	568-852	0-20	0-568	2,840
$	60-70	18,13 – 21,15	20-30	6,04 – 9,07	0-20	0-6,04	30,22

On the opposite of the existing expenditures are the revenues through service fees or door-to-door collections. These charges for the waste management are about 2 %of the municipal own source revenue and cover about 5% of the waste management expenditures.(ADB, 2013)

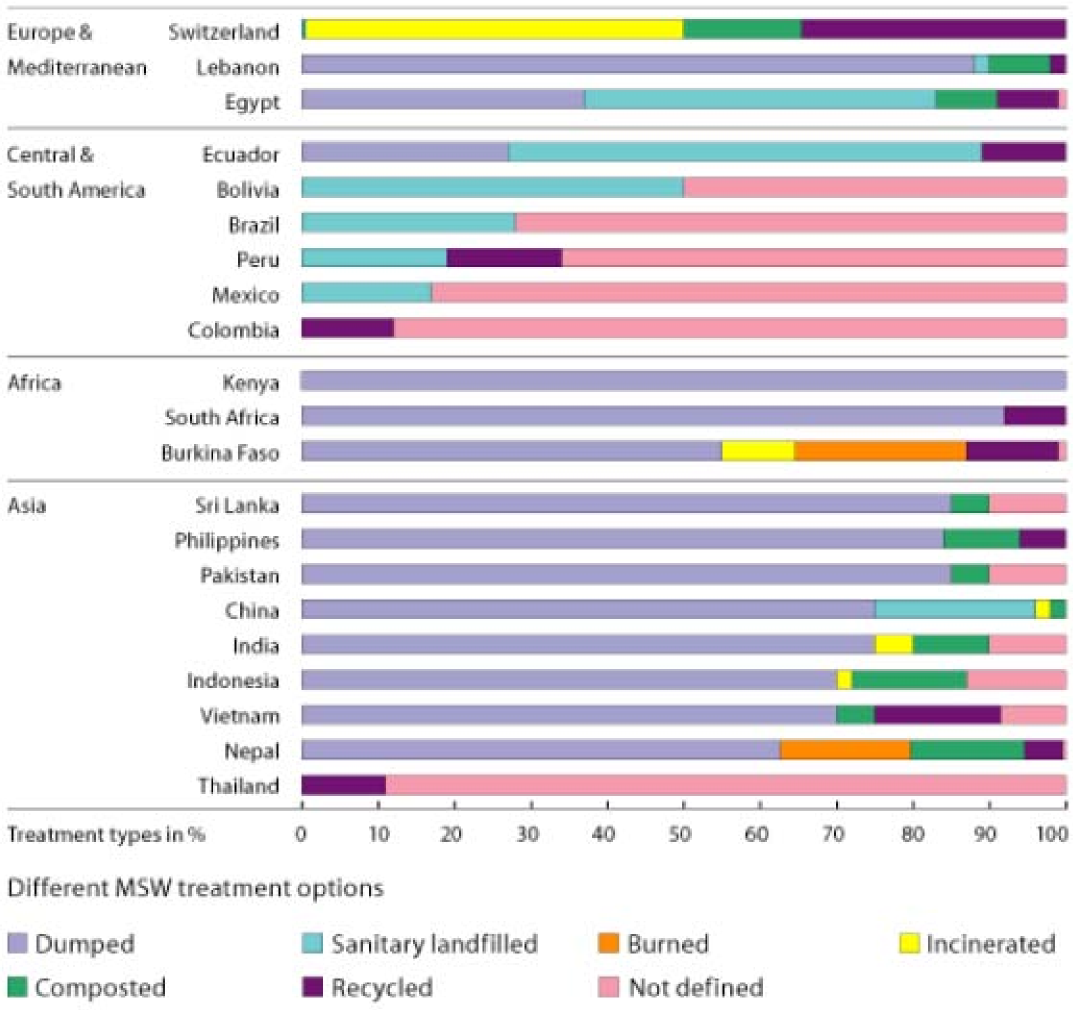


Figure 8: Percentage of the commonly used municipal solid waste treatment and disposal technologies; (Vögeli and Sylvie, 2008)

The possibilities for solid waste treatment are dumping, burning, composting and recycling. The major applied solid waste treatment in Nepal is dumping followed by open burning.

Nepalese average work wage

The average work wage for a Nepalese citizen is about 3,400 Nepalese Rupees (35 $) per month (Statistics, 2008). Which would make 860 Rs (8,6 US$) per week and 22 Rs (0,22 $) per hour.

Average transport costs for air cargo and porters

On the subject of transport costs by kilogram from Kathmandu to Lukla cost 150 Rs (1,50 $) per air cargo.

The transport costs per porter and kilogram is mounted with 35 Rs (0,36 $) within the SNPBZ (Zuser et al., 2011).

Figure 9: The typical Nepalese basket for transporting goods within in the SNPBZ; (Own figure)

3.3 Nepal's legal background for waste management

This chapter shows the nationwide regulations and acts which are concerned with waste management in view of the Sagarmatha National Park. A detailed collection in reference of the legal suit of the Sagarmatha National Park and Buffer Zone is carried out in the SNPBZ chapter.

3.3.1 Solid Waste Management Act, 2011

In the year 2011, the Nepalese Government enacted and enforced the "Solid Waste Management Act 2011". (SWMA 2011)

The main objective of this act is to address the most urgent problems related to solid waste management. The Solid Waste Management Act makes arrangements for the systematic and effective management of solid waste by minimizing the solid waste at source, re-using, processing or disposing of the solid waste, and to maintain the clean and healthy environment by minimizing the adverse effects of the solid waste in the public health and environment. (MUD, 2011)

Responsibility for the organisation of the collection, transportation and treatment of solid waste lies in the hands of the municipalities. This also includes the construction, operation and managing of the infrastructure for solid waste management.

It is also statutory that the private sector, community base organisations (CBO) and non-governmental organisations (NGO) are included into the waste management service. This inclusion can be realized through competitive bidding and authorizes the successful bidder to provide services for waste management against fees respectively taxes.

The SWMA can also authorize local bodies to formulate rules, guide-lines and by-laws in consultation with the municipal board.(MUD, 2011)

There is a specific foreword to hazardous waste as also a definition of hazardous waste by approximation.

3.3.2 Solid Waste Management National Policy, 1996

As the national regulation was enacted, there were no reliable statistics about the waste appearance, collection, treatment and disposal.

The main objectives of the national policy are to minimize the adverse effects of waste on human health and nature, and to mobilize the waste as a resource to recover and to make the work solid waste management as simple as possible. Further on it tried to involve the broad public in waste management. This means that the policy wanted to include both civilians and organisations, to spread public awareness for waste management. (MLD, 1996)

The Nepalese government works on the waste problem according to the “3R- Hierarchy”. This Concept departs itself into:

1. Reuse
2. Reduce
3. Recycle.

Hence, the local bodies should be competent in waste management related problems, but the work should be done privatized in different stages of the waste management process. (MLD, 1996)

There is no specific foreword about hazardous waste.

3.3.3 Dhaka Declaration on Solid Waste Management, 2004

The Dhaka Declaration was an international workshop for the South Asian Association for Regional Cooperation (SAARC) Countries, under which Nepal is covered.

One aim of this declaration is “an effective, efficient, affordable, safe and sustainable waste management system of all the urban/ rural settlement of SAARC countries with special attention to addressing the needs of the poor”. The overarching goal is to stop the open dumping immediately and replaced through new safe disposal facilities. (MEF, 2004)

Among targets to undertake activities like; exchanging information about best practised waste management and other international institutional exchange, there are decided objectives for hazardous waste:

- In absence of an appropriate no-burn technology, incineration should be considered for the treatment of infectious/ hazardous bio-medical wastes
- SAARC countries agree that hospital waste may be treated as a special waste and managed separately. (MEF, 2004)

3.3.4 **Town Development Act, 1998**

The Town Development Act is more a guideline than a law for local bodies to develop their villages and respective towns according to a certain plan.

In face of “growing population, urbanization growing population and urbanization, it is expedient to provide for necessary provisions in order to provide necessary services and facilities to the residents” (MHPP, 1998) and further on “to maintain health, convenience and economic interest of general public”. (MHPP, 1998)

There is no explicit reference about waste or hazardous waste. It is obvious in the above objectives about economic interests and general public, that waste management and especially hazardous waste management is an intrinsic field on the way to the contemplated objectives.

3.3.5 **The Industrial Enterprises Act, 1992**

Similar to the “Town Development Act 1998”, the “Industrial Enterprises Act, 1992 (IEA, 1992)” is a regulation which guides the industrial development in Nepal. The act is the main document for the industry and aims to provide a better surrounding for industrial investments. (Board, 1992)

In the case of the National Park, the local industries there are classified as “Tourism industries”, “Agro and Forest - Based industries” and “Cottage industries”. As the first two industries are self-explanatory, the classification “Cottage Industries” needs a further description.

“Cottage Industries” according the IEA, 1992 are: “The traditional industries utilizing specific skill or local raw materials and resources, and labour intensive and related with national tradition, art and culture mentioned in Annex 1 shall be named as cottage industries”. (Board, 1992)

Annex 1 specifies the industries that are not “Cottage Industries” which are enterprises that are processing and dealing with alcohol and tobacco.

Further, the Solukhumbu district is classified as remote area and shall be granted after the IEA, 1992. (Board, 1992)

The “Solid Waste Processing Industry” (Board, 1992) is named as “National Priority Industry” and underlies a governmental permission because it could have a significant adverse effect on environment and public health. (Board, 1992)

There is no specific definition or correlation with hazardous waste in the context of this act.

3.3.6 **Tourism Act, 1997**

The Tourism Act is a regulation about common tourism and its development in Nepal. One aim of this act is to position Nepal in the international tourism arena as an attractive and attainable destination. Besides creating as much employment as possible within the tourism industry, the cultural and environmental protection should be also promoted. The local bodies should overtake through several undefined activities the duty of protection. (Board, 1997)

There is no advice about the protection of the environment, waste management or hazardous waste management.

3.3.7 **Environment Protection Act, 1997**

The “Environment Protection Act, 1997 (EPA, 1997)” is the cornerstone of the environmental protection in Nepal. The objectives of this act are to minimize the adverse effects from environmental degradation on “human beings, wildlife, plants, nature and physical objects”. (MPE, 1997)

According to the EPA (1997), “waste” are defined as “liquid, solid, gas, slurry, smoke, dust, radiated element or substance or similar other materials disposed in a manner to degrade the environment.”, and “disposal” means the act of emission, storage, or disposal of sound, heat or wastes.

For world heritage sites, the government of Nepal is in charge to prevent any decline of protection, furthermore the government is in force to declare new heritage sites in order to protect the above named subjects of protection. (MPE, 1997)

An important burden of the Act is also, “that a proponent shall have to carry out Initial Environmental Examination and Environmental Impact Assessment (MPE, 1997)” of planed activities, than have the ability to cause negative environmental impacts. In order to control these assessments, an “Environmental Inspector” is in charge. (MPE, 1997)

3.3.8 Environment Protection Rules, 1997

The Environment Protection Rules (1997), are based on the Environment Protection Act (1997) and constitute the embodiment of the EPA (1997).

It is prohibited to emit waste, regulates the control on certificated pollution and to seize immediately measures against polluting.

The most important reference in view of hazardous waste is that there are explicit construction activities named, in order to treat and dispose hazardous waste according to the following nature:

- Construction of waste plant:
- Construction of waste recovery plant.
- Constructing of a site for filling accumulating or burying waste.
- Construction of a site to store the waste.
- Construction of a waste treatment facility (GOV, 1997)

3.4 Introduction into hazardous waste

Common treatment of hazardous waste in developing countries

Within the solid waste, hazardous waste is imbedded. Hazardous waste levels in developing countries are lower than in industrialized countries. The reason is the lower level of commercial, industrial and institutional establishments. Hazardous waste in developing countries is not properly managed and is often co-disposed with general solid waste in open dumps and controlled landfills. The open and uncontrolled dumping without leachate or gas catchment is the most common type of waste disposal. Another treatment is the open burning. Technical engineered operated landfills or incinerators are rare. (Marques, 2012)

Dangers of hazardous waste

(1) Surface water contamination

Changes in the water chemistry due surface water contamination may affect the ecosystem. Possible impacts are on organisms in the food chain and furthermore the availability through the food chain. The health of animals and humans is influenced by contaminated water. Water organisms may accumulate and concentrate contaminants in their bodies. With ingestions the dose of contaminants is higher than being directly exposed. (Vögeli and Sylvie, 2008)

(2) Groundwater contamination

Contaminated groundwater may affect animals, plants and humans. Depending on the geology, groundwater is arising to the surface. In many parts of the world, groundwater is the primary source for drinking, bathing and other household uses. Agriculture and industry are further causes for possible contaminated groundwater. (Vögeli and Sylvie, 2008)

(3) Air contamination

Through respiration, contaminates may enter the lungs and the target organs. Certain air contaminants may harm animals, humans and plants. (Vögeli and Sylvie, 2008)

(4) Leachate

Leachate is water which has entered contaminated areas and leaches out with chemical exposure. Chemical exposure leachate occurs at landfills, pesticide, fertilizer and bacteria exposure leachate in appears in the agriculture. Through leachate, hazardous contaminants may enter soil or surface water. (Vögeli and Sylvie, 2008)

(5) Soil contamination

Soil as basis for livelihood is sensitive regarding hazardous substance. Plants take up contaminants. Through touching, ingestion or inhaling contaminated soils, adverse health impacts may affect humans, animals. (Vögeli and Sylvie, 2008)

Definitions on hazardous waste

The organization for a proper collection, handling, transportation, treatment and storage respectively disposal, is to have a clear definition on hazardous waste. To define, it is necessary to understand and identify what could hazardous waste be and where the origin of it is. (UNEP, 2012)

The definitions and classifications on hazardous waste are founded by international organisations like the United Nations (UN) or European Union (EU), are converted by agencies into national regulations. Hazardous waste definitions have in common that they define hazardous waste as a potential unacceptable risk for public health and environment. According to the UNEP (2012) for most developing countries like Nepal, in this first step, the definition on what hazardous waste is lays a big challenge. Hazardous waste especially needs a well elaborated definition, because of its special character mostly defined as “poisonous”, ”toxic” or “chemical”. Alternative characteristics are the source, composition, physical form or the chemical, physical and biological properties. (UNEP, 2012)

There is no national information on hazardous waste available for Nepal because of the lack of an existing definition on the global map from the United Nations Statistics Division. (UNEP, 2011)

International definitions characterise hazardous waste with four typically properties:

1. Toxic and eco-toxic
2. Corrosive
3. Ignitable
4. Reactive.

In comparison to the “Nepalese Solid Waste Management Act 2011” and the local definitions on hazardous waste, selective definitions of hazardous waste will be introduced.

3.4.1 Hazardous waste definition according to EPA

The Environmental Protection Agency (EPA), in the USA, in the year 1976 enacted the “Resource Conservation and Recovery Act (RCRA)”. The objectives of this act are the protection of the human health and environment from potential hazards of waste disposal.

Under hazardous waste falls every waste which is included into a specific list. There is the possibility that the waste is tested and has to fulfil at least one of four characteristics like; ignitable, corrosive, reactive or toxic. (EPA, 1976)

To relieve the regulations for retail stores and those who wish to collect the waste like municipal programmes to reduce the quantity of hazardous waste in their landfills, there is the special standard of the “Universal waste.” (EPA, 2012)

At least the producer of the waste has the ability to declare it hazardous. (EPA, 1976)

3.4.2 **Hazardous waste definition according to the Basel Convention**

The Basel Convention came into action in the year 1992 in order to control the trans-boundary movement and disposal of hazardous waste. The UNEP introduced an international standard on hazardous waste definitions.

The objectives of the Basel Convention are to protect human health and the environment against the adverse effects of hazardous wastes. Its scope of application covers a wide range of wastes defined as “hazardous wastes” based on their origin and/or composition and their characteristics. (UNEP, 1989)

The Basel Convention is separated into 45 categories of hazardous waste. The first 18 categories are waste streams in which hazardous waste arises, remarked in the “Annex I” from the Basel Convention. This streams are for example : “Clinical waste from medical care in hospitals, medical centres and clinics.” (UNEP, 1989)

The categories from 19 to 45 remarks wastes solitary that have identified constituents that can be harmful like: “Lead, Lead compounds” or “Mercury, Mercury Compounds”. Additional to one of the constituents it is obligated that the waste items have at least one of 14 hazardous characteristics, like flammable, corrosive or ecotoxic. (UNEP, 1989)

In “Annex A”, the listed waste is definitely hazardous waste while in “Annex B”, the waste is definitely not considered as hazardous. If waste falls in one of these lists, no further testing is necessary.

For this thesis, the Basel Convention is used to identify hazardous waste. Also the Basel Convention offers a worldwide agreement on hazardous waste in comparison to the EPA or the European Waste Catalogue.

3.4.3 **Hazardous waste definition according to the European Waste Catalogue**

Like the Basel Convention from the UN, the European Waste Catalogue (EWC) is organized as list.

With the waste catalogue, a legal framework for waste and especially hazardous waste for the European Union is given, which contains 850 types of waste.

The hazardous waste itself is divided into 19 main categories and has 420 classified sorts of hazardous waste. (Commission, 2002)

Same as in the Basel Convention, wastes that are listed as hazardous have to fulfil further tests and display at least one of mandatories characters. (Commission, 2000)

3.4.4 **Hazardous waste definition according to the Nepalese Solid Waste Management Act 2011**

The “Solid Waste Management Act 2011” regulates the management of solid and hazardous waste in Nepal.

There are no explicit categories, listings or mandatory characteristics that hazardous waste has to fulfil. The definition on hazardous waste is: ““Hazardous Waste” means the goods, substances and radioactive rays discharged in different forms which cause to degrade the natural environment and harm human health and the life of other animals.” (MUD, 2011)

There is no testing or typical characteristics of hazardous waste described like in the Basel Convention.

Hazardous waste is further mentioned as part of “Industrial Solid Waste”, “Solid Waste”, “Chemical Waste” and “Medical Waste”. The closest description on hazardous waste delivers the “Solid Waste” definition. Under the definition of solid waste are the first named waste types “plus solid, liquid, gas, semisolid, smoke, dust, and materials used by the electronic and information technology, which are not in a position to be used forthwith, thrown or rotten, or disposed causing degradation of the environment.” (MUD, 2011)

Responsible for the processing and managing hazardous waste is the waste generator otherwise; it is possible for industry or medical institutions to take up the responsibility for the hazardous waste. These institutions would then be responsible for waste fees. It is also allowed for the named institutions to use the sanitary landfill from the local body (MUD, 2011)

It is also forbidden to discard hazardous waste in the solid waste collection centre or transfer station, although hazardous waste can be a part of the “Solid Waste”. (MUD, 2011)

There is no legislative description about the collection, transport, treatment, storage or disposal of hazardous waste. The duty of collection, treatment and disposal of hazardous waste lies in the hands of the local body.

3.5 Fate and transport of contaminants from hazardous waste

This chapter deals with the comprehensive theme about the transportation of contaminants and its direct and indirect consequences for the surrounding environment.

The rate and transport of released contaminants is constituted in the following chapter. It is difficult to describe all of these processes with a lack of information, it is the aim of the following to give a very basic understanding of how contaminants are influenced and influence the environment.

With a basic understanding, contaminant conditions, transformation through transportation and absorption, a fundamental component for hazardous waste management is given. Small quantities of toxic and hazardous chemicals may have an enormous impact on water and environment and livelihood. For a clear statement on transport and the end points of contaminants in the subsurface and atmosphere and the possible contamination loads on receptors, a monitor on site is demanded.

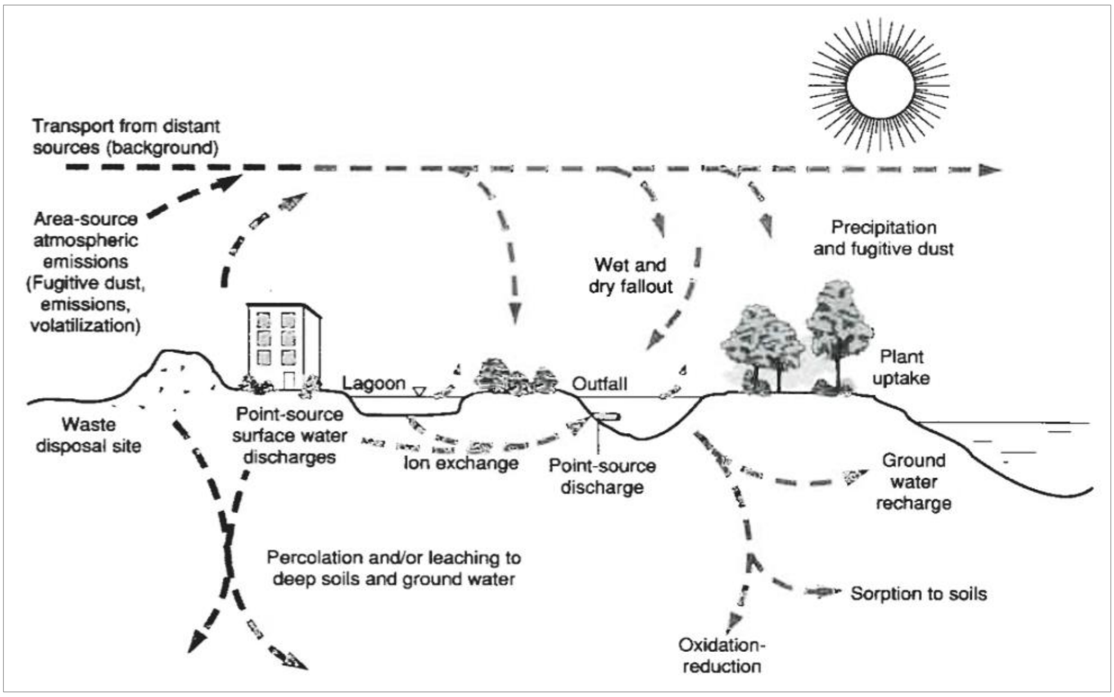


Figure 10: Fate and transport of contaminants; (LaGrega et al., 1994)

The paths of contaminants are associated with natural paths of e.g. water. Contaminants take complicated paths through the atmosphere, surface, subsurface and aquatic envionment. The understandig of the relationships between these spheres is the key for an understanding of the circular movement of contaminants. It is necesseray to understand the impacts caused by human ativities, in form the of waste treatment, incineration and disposal.

The release of contaminants from dumps with hazardous waste fractions may occur in one or more of the following three possible phases:

(1) Gas – e.g.: fly ash potentially laden with toxic metals
(2) Liquid – e.g.: Leachate to ground water, contaminated runoff, discharges to surface water
(3) Solid – e.g.: fugitive dust, suspended solids

The release of contaminants may happen in a controlled or uncontrolled manner. The controlled release of contaminants with the aim to avoid or minimize possible damage in an existing and functioning ecosystem, has a prominent role in comprehensive hazardous waste management. (LaGrega et al., 1994)

Air emissions

Air emissions may appear in different forms, like a "point, line, area, volume or puff sources". (LaGrega et al., 1994) In anticipation to the SNPBZ, point (incinerators, open fire pits) and area (dumps) sources are predominant.

The releases can be classified as gas-phase emissions, or particulate matter emissions. (LaGrega et al., 1994)

Gas-phase emissions, induced through volatilization, consist majorly of organic compounds. Gaseous emissions are generated by waste treatment processes. "The volatilization is the predominant source of atmospheric emissions at most uncontrolled hazardous waste sites" (LaGrega et al., 1994) and describes the transfer from a liquid phase (e.g.: leachate, surface runoff) to a gaseous phase. The rate depends on atmospheric and local conditions like temperature and vapour. (LaGrega et al., 1994)

Particulate matter emissions, in fine particles, are generated through mechanical processes and wind erosion. These contaminants may have a broad spectrum of metals and normally immobile substances. As source for these emission can also incinerators be seen, which discharge them directly into the air. Fugitive dust comes from hazardous waste sites. Dust as the same contaminants as those which are adsorbed to the soil. (LaGrega et al., 1994).

Landfill leachate

Leachate presupposes the water in form of precipitation, surface flow, or ground water inflow gets in contact with dumped waste. The amount of leachate that is produced depends on various factors; one of them is the ability of the waste itself to absorb water, not till then water moves through the waste and becomes contaminated. This depends on the leachable share of contaminants in the waste, the ability of transfer and the infiltration rate.

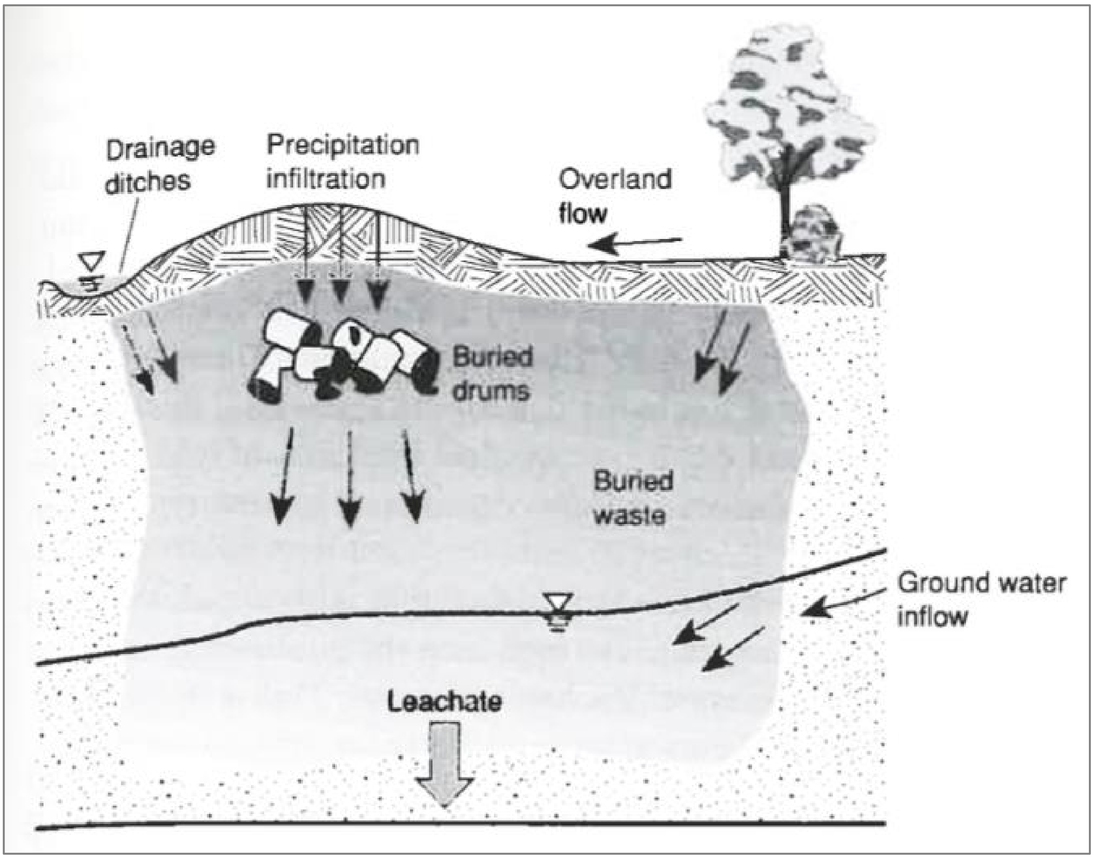


Figure 11: Sources of fluids for the generation of landfill leachate; (LaGrega et al., 1994)

Controlled release of contaminants to surface water flows and the concluding dilution is a widely applied technique for hazardous waste sites. This technique takes place under controlled conditions from engineered landfills. Controlled contaminants released to the ground water are barely applied. (LaGrega et al., 1994)

To avoid an infiltration of water to a dump, different covers, ranging from sheltered dumps to geo textiles are possibly installed. The contaminant concentration in leachate is varies between medium to high, while the surface run off has a possible low concentration on contaminants, the volume of the named leachate types are low but also varying with the atmospheric entry of water. (LaGrega et al., 1994) The concentration of contaminants can be high, while the actual volume of leachate can be low. The distribution of contaminants within the waste body is also varying like the concentration in the leachate. If there is no coverage or leachate catchment or drainage system installed, water can unhampered entry into waste and unfiltered leachate can unhampered enter the surrounding soil.

3.5.1 Transport of contamination

The transport of contaminants predicts two conditions: A contaminant and a media in which the contaminant is mobile or immobile. The contaminants may appear through waste disposal practises, like dumps.

Subsurface transport

The source of contaminants appears in different forms. Talking about hazardous waste contaminants from dumps, the source can be described as a continuous point source, Which constantly emits toxic agents into the two-phase system of groundwater and solid constituents. First phase is the ground water in the role as solvent, second phase is the constituent part.

Contaminants are distributes and reduced mainly in three ways:

(1) Dispersion
(2) Dilution
(3) Diffusion

In the named cases, dispersion, dilution and diffusion, water is playing a prominent role. Water is the solvent, in which dissolvable contaminants are solute. In a solute stadium, contaminants are transported with groundwater in a specific direction of flow, what is termed advection.

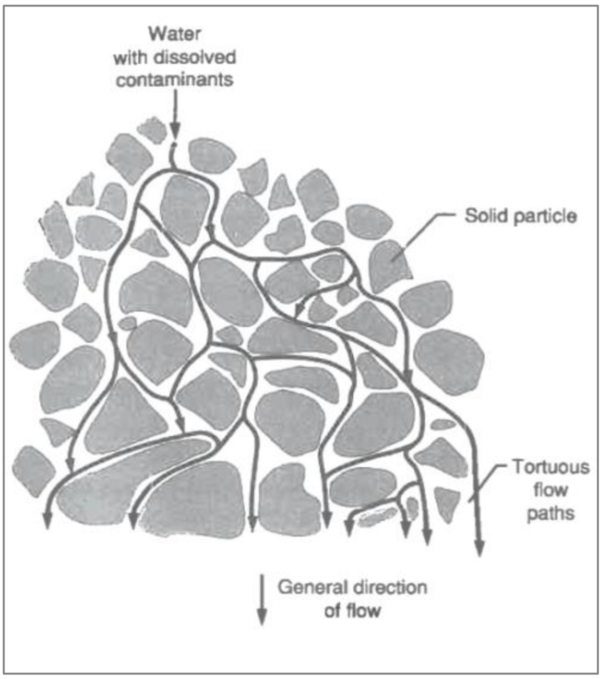


Figure 12: Mechanical dispersion of contaminants; (LaGrega, Buckingham et al. 1994)

Mechanical dispersion is the repeated process of water particles floating around solid particles. The main effect is the dispersion of the contaminant flow beyond the point it would disperse without mechanical dispersion. The other possibility is the dilution, which means the mixing of groundwater with contaminated water.

Beside dispersion and dilution is diffusion. Diffusion is the transport of a contaminant according to its chemical reaction. There are various processes which have an influence on the transportation of a contaminants transport, which are departed into mechanical, chemical and biological processes.

Atmospheric transport

The atmosphere transports the gaseous residues from a burning process is determined. Factors which influence the transport are the plume properties, wind, and the atmospheric turbulences. Factors which influence the transportation of contaminants are the rise of the exhausted plume and the dispersion of the plume. Aim of an atmospheric dispersion of contaminants, is to keep the ground level concentration of contaminants as low as possible for possible receptors.

Therefore, the height of the stack is important, the higher the stack, the lower the contaminants concentration at ground level downwind from the source.

Figure 13: Incinerator in Lukla with low stack; (Own figure)

The dispersion and dilution of incinerated releases proceeds mainly with the wind. The direction in which pollutants are transported is also mainly influenced by the wind. The

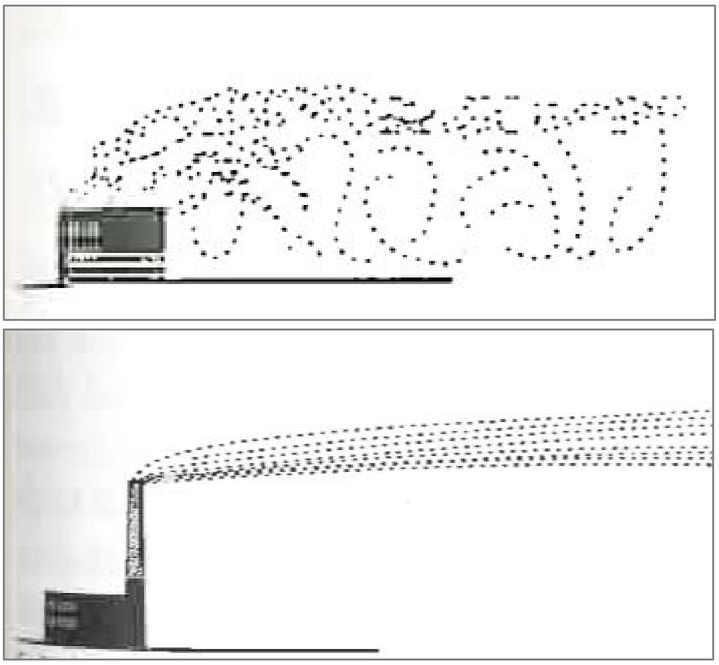


Figure 14: Emissions from roof-top exhaust in comparison to high stack exhaust; (LaGrega, Buckingham et al. 1994)

turbulences within wind have a major impact on the settlement of pollutants. The link to atmospheric stability is closed and the results from a local monitoring give answers on the actual administered dose of contaminants on receptors.

Definition of the actual administered dose is the so called “Maximum Ground Level Concentration (MGLC)”. The MGLC is influenced by the named impact factors; effective stack height, wind speed and stability class. Stable atmospheric conditions and moderate wind speeds cause the most concentration to the ground, founded in the counterbalanced effects of plume rise and wind dilution, the actual cases for the MGLC may only be searched on site through measurements.

3.5.2 Fate of contaminants in the subsurface

The fate of contaminants in the subsurface is determined through a countless number of processes and connected effects. Most of these processes slow the movement of contaminants or attenuate the concentration.

Slowing of contaminants in the subsurface

Slowing of contaminants means a immobilizing or removing contaminants from a free state (e.g. contaminants in solute or gaseous state). Slowing process doesn´t mean that the contaminants are transformed or are staying in an irreversible immobilized state. Reversal slowing processes are possible if, the contaminants concentration is decreasing and the slowed quantity of contaminants is stable.

Examples for slowing processes are:

(1) Sorption of organics: This process is the partitioning of chemical constituents into phases. In the specific case of contaminants from hazardous waste, this means the accumulation of organic chemicals to the soil surface.
(2) Ion Exchange: Can be seen as a subcategory of sorption involving electrostatic interactions.
(3) Precipitation: The exceeding amount of a specific substance out of a solute through adding a flocking agent.
(4) Filtration: Describes the physical form of slowing, as a result of clogged pore.

Attenuation of contaminants in the subsurface

The attenuation is divided into two processes:

(1) Irreversible removal: In difference to the retardation, reduces the attenuation the mas of a contaminant, through a transfer to another media.

(2) Transformation: In this attenuation process, the molecular structure of the substance is transformed.

3.6 Impacts from hazardous waste on the environment and mankind

To describe the potential impacts of hazardous waste on environment and mankind, the UN-Basel Convention classifies nine hazardous characteristics (UNEP, 1989), which overlaps with the four characteristics from the EPA definition on hazardous waste. The four of hazardous wastes are the ignitability, reactivity, corrosivity and toxicity ignitability. (EPA, 1976) These characteristics and their potential for ecotoxicity have caused the necessity for clear restrictions and regulations for hazardous waste, with the aim of abating a harmful or toxic influence on humans, animals and/or the environment.

The following chapter discusses a view on toxicology. From the intake of contaminants into the body, the distribution and storage in the body itself and possible diseases which maybe caused from hazardous waste on humans.

3.6.1 Exposures to hazardous waste

There are several steps along the “exposure pathway,” (LaGrega et al., 1994) from the release of contaminants to the point of the interface with the human body. The three main exposure routes from environmental contaminants into the body are through inhalation, ingestion and dermal contact. (LaGrega et al., 1994)

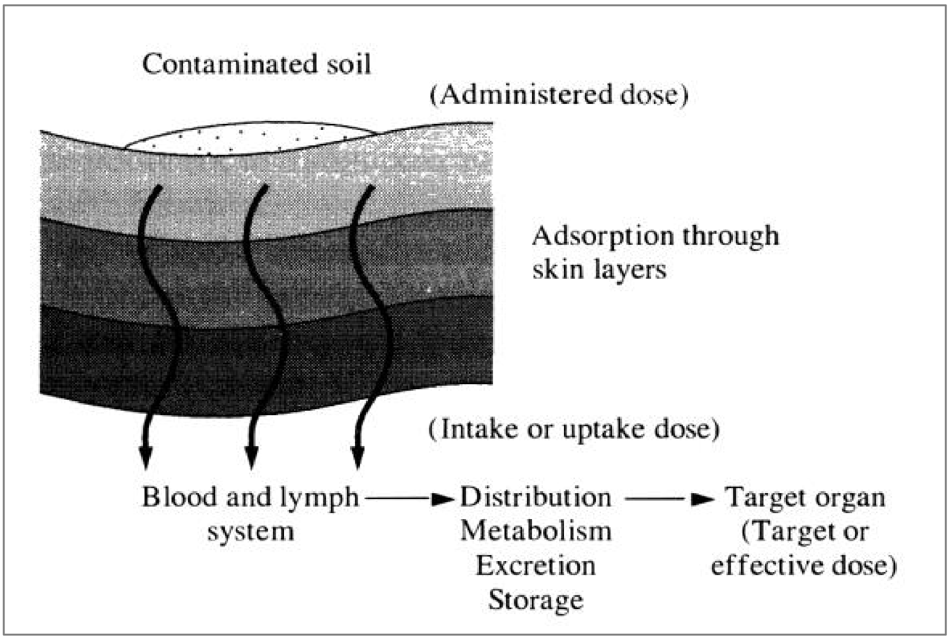


Figure 15: Illustration of types of doses for dermal contact with contaminated soil; (LaGrega, Buckingham et al. 1994)

At the beginning of every intake of the toxic agent is the dose itself which comes into interaction with the mammal body. The first absorbed, administered dose of toxic agent is called the intake or uptake dose. The uptake dose will be partly absorbed, while the rest of the dose becomes available for the body and respectively vulnerable organs. The uptake dose will be transported via the blood and lymph system further through different stages of the distribution, where it will be then partly absorbed and becomes later an available dose and consequently an effective dose for the specific vulnerable organ of the toxic agent. How much of the administered dose becomes the target dose depends on various parameters which are individual for every mammal organism. (LaGrega et al., 1994)

Absorption mechanisms and diffusion

Chemical substances like toxic agents may pass through the tissue, the internal and external barriers for protection of organism, in two ways:

1. Through cellular membranes by passive or active transport (diffusion).
2. Through pores or channels.

The first way of passing toxic agents through cellular membranes, the simple diffusion is the most common type of in taking contaminants. “The rate of diffusion depends upon the chemical and physical properties of a toxic agent. (LaGrega et al., 1994) The most important chemical property is the lipid solubility, the lipophilic, the affinity of chemicals to solvent in fat-like (lipids) liquids. In contrast to the hydrophilic, the affinity of chemicals to solvent in water-like substance (e.g. blood, urine).

Absorption by ingestion

Toxic substances can be absorbed along the whole gastrointestinal tract with the daily alimentation. There are many factors of influence on the ability of absorption heavy metals. The presence of chelating agents, which means a chemical complex compound occurring in vitamin B12 (animalistic groceries) or chlorophyll (plants), can alter the intake of heavy metals. Zinc (milk products) on the other hand may decrease the uptake of cadmium. (LaGrega et al., 1994)

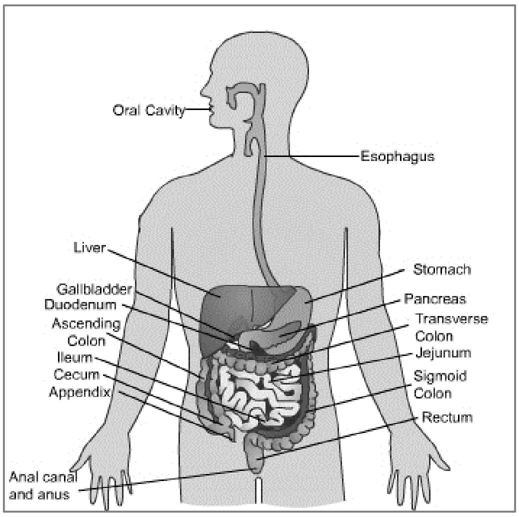


Figure 16: Exposure routes for toxic agents from hazardous waste, via ingestion;(Virginia, 2014)

Absorption by inhalation

The absorption from toxic compounds via inhalation is done by diffusion between inhaled air and the surface of the lungs. It depends on the size of the inhaled particles where it will be transported and finally deposited. Particles with a diameter of 2µm and above are deposited in the respiration tract and removed from airways and finally swallowed. Smaller particles are deposited in the alveoli, direct in the lung. Generally the deposition of gases which arise out of e.g. burning processes depends on various parameters which are individual to every mammal like convection, diffusion, and solubility. (LaGrega et al., 1994)

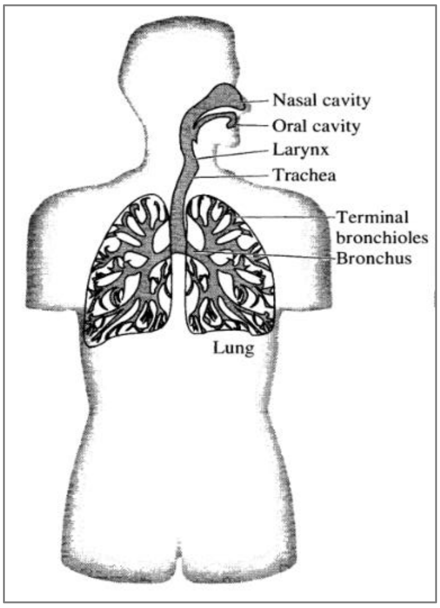


Figure 17: Exposure routes for toxic agents from hazardous waste, via inhalation; (LaGrega, Buckingham et al. 1994)

Absorption by dermal contact

The skin represents a very effective barrier to toxic agents. The dermal contact tolerates from 100 to 1000 times more the amount of exposure than ingestion or inhalation. Naturally there are exceptions existing, like lipophilic or hydrophilic compounds.

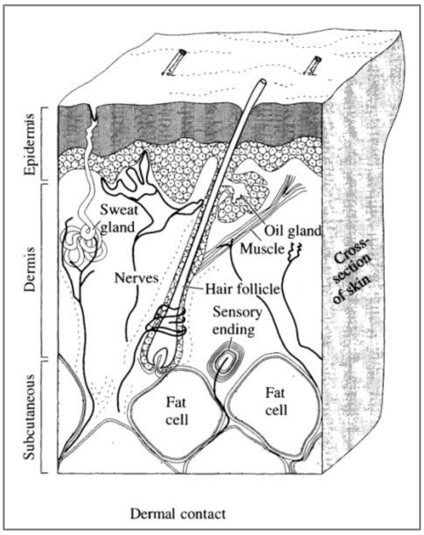


Figure 18: Exposure routes for toxic agents from hazardous waste via skin; (LaGrega, Buckingham et al. 1994)

Distribution of toxic agents

If a toxic agent has entered the blood stream, it freely may flow through the body. Only a few toxic agents attack at the entry point, the greater number of toxic agents attack as above mentioned, systemic and an explicit organ. Through the a partial absorption a toxic agent is able to appear in different parts of the more concentrated than in others, what further means that the whole administered dose is not automatically averaged.

The absorption governs also the transmission of toxic agents from blood to tissue and adverse. Organs that are highly supplied with blood are the liver and the brain. The liver delicately screens for toxic agents, while the brain has some sort of protection through the blood-brain-barrier. (LaGrega et al., 1994)

Storage of toxic agents

"Storage" means in this context, the ability of toxic agents to remain accumulated in high or even high concentration as in the target organ outside the target organ. This could happen even if high concentrated, without any negative consequences for the storage medium and can be released from there over a certain period of time.

Important storage media are:

- Fat compounds: Pesticides, PCBs
- Blood plasma for compounds bound by blood proteins: mercuric irons
- Bone for lead, radium and fluoride
- Kidneys for cadmium (LaGrega et al., 1994)

3.6.2 Diseases accused from toxic agents

The following listed heavy metals are part of found hazardous waste items in the SNPBZ. It is not exact that theses heavy metals are occurring on a dangerous level to health but it is highly probable that these heavy metals are appearing in accumulated form on the specific waste treatment and dumping sites in the SNPBZ.

Cadmium, (Cd)

Cadmium is highly toxic in low doses. Symptoms for cadmium exposure are flu-like symptoms like fever, chills and muscle aches. It is stored in the liver and kidneys and my lead to the irreversible outage of the kidneys which have the ability to remove acids from the blood. (UVA, 2014) Cadmium also known for softening the bones and may also cause the loss of bone mass and weaknesses of bones. It also is acts as carcinogen and can damage the lungs. (Labor, 2014)

Chromium (VI), (Cr VI)

Chromium occurs from industrial processes like storage from industrial waste and is found in water. It is likely a carcinogenic when ingested. (EPA, 2013) Adverse health effects associated with Chromium are asthma, eye irritation and damage; further Respiratory irritation, kidney and liver damage, erosion and discoloration of teeth. All Chromium compounds are considered as carcinogenic to workers, the probability of to be taken by cancer increases with the length of the exposure. (Labor, 2014)

Lead, (Pb)

Lead can find multiple pathways into the body. The main exposure is through eating and drinking, but also by breathing lead dust from lead containing paints. (EPA, 2014) It is an accumulative hazard. Children and elderly people are especially endangered. Children may be more sensitive on the intake of lead because their central nervous system and brain is still developing, even low levels of intake ma cause learning disorder, stunted growth and kidney damages. At high levels of lead, ataxia, convulsions, death and stupor may occur. It also may cause depression, forgetfulness, impotence and weakness. (UVA, 2014)

Manganese, (Mn)

Manganese occurs in air, soil and water and is an essential nutrient for humans and animals. Although it is a nutrient, over exposure may lead to negative health effects. The main form of intake is via digestion with food but also the intake by dermal contact and vapour is possible. Specific concrete health aspects may appear as lethargy and increased muscle tonus. Groups which are sensitive to an overdose of manganese are infants and elderly people. (EPA, 2014)

Mercury, (Hg)

The intake of mercury is mainly through mercury vapour. (UVA, 2014) Short term symptoms can affect the central nervous system with the effects of tremors, mood changes and slowed sensory and motor nerve functions. Long term effects could be erythrism, irritability, excessive shyness and tremors. Also mercury is responsible for kidney damages. (EPA, 2014) Further symptoms are tremors, muscle twitching, difficulties in speaking and thinking clearly and hallucinations. Aroused are these symptoms through chronic exposure to mercury, the damages are irreversible. (UVA, 2014)

Nickel, (Ni)

Nickel is a natural occurring element and can be found in small amounts in food, water, soil and air. Like with Manganese, food is the major source for the intake of nickel via digestion. Acute effects are likely in the lungs and kidneys, also vomiting and diarrhoea and neurological effects are possible. There is also a broad spectrum of negative health impacts occurring like dermatitis, asthma and bronchitis. Nickel salts may especially cause higher risk of cancer. (EPA, 2014)

Zinc, (Zn)

Zinc enters the body mostly through the gastrointestinal tract and is one of the most abundant trace elements. Overconsumption normally has not automatically lead to concerns. A heavy intake of zinc can lead to a lower influx of calcium, which can cause in extreme cases to cell and neuronal death. (UVA, 2014)

3.6.1 **Available hazardous waste treatment facilities in Nepal**

Nepal struggles, due its difficult financial situation with establishing a comprehensive general waste management program which would include a hazardous waste management. There are small-scaled treatment possibilities in Nepal.

Batteries

A battery recycling business is “Local Battery Manufacturing” situated in Nepalganj. This business has the documented knowledge and skill to recycle batteries in an elementary fabrication process. There are no references regarding the manageable input of this manufacturing unit. (Services, 07.26.2010)

Compact fluorescent light bulbs, gas cartridges, lubricant and paint cans

For these items no recycling or disposal sites are in Nepal. An option for disposal is an engineered sanitary landfill, although it has to be mentioned that built landfills in Nepal are struggling with contamination to the ground and poor leachate management. (Khanal, 2012.)

Infusion bags, Injections and Medicaments

For medical waste management, the best available facilities are found in Kathmandu, where already installed waste treatment facilities are existing and may be used for medical waste from the SNPBZ. (MoH, 2003) The co-incineration in a brick-factory is not suitable, as the safety standards for workers are very low and child labour cannot be excluded. (ILAB, 2014)

3.6.2 **Conventional hazardous treatment systems**

Basically hazardous waste treatment can departed into:

- Physical/chemical treatment systems
- Biological treatment systems
- Thermal treatment systems
- Land disposal systems (Kutz, 2009)

Physical, chemical and biological treatment systems are for example, for air stripping or water oxidation. Suitable treatment systems for hazardous waste in the SNPBZ are thermal treatment system and land disposal.

Thermal treatment systems

Incineration systems are designed to destroy only organic components of waste. Most hazardous waste contains combustible organics and non-combustible inorganics. With destroying the organic fraction, incineration reduces the waste volume to the extent that the organic components include toxic components and its threat to the environment. Gases are not counted as hazardous waste. (LaGrega et al., 1994)

A complete combustion is the complete oxidation of organic compounds with air. Also Organic compounds are possibly confined to carbon, hydrogen, oxygen, metals and non-metals. Combustions are affected by:

- Time
- Turbulence
- Temperature

Only a few combustions are complete. (LaGrega et al., 1994)

The following information on to be burnt waste is required to engineer a thermal treatment:

- Chemical composition
- Heat of combustion
- Viscosity
- Corrosivit
- Reactivity

A possible incinerator for hazardous waste is a “Rotary Kiln Incinerator”. (Lechner, 2004a)

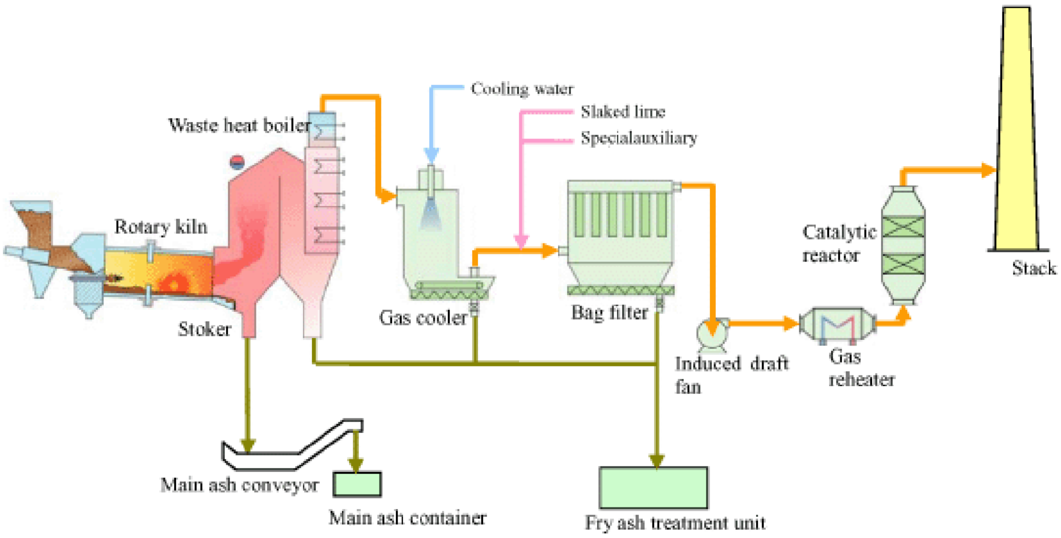


Figure 19: Rotary kiln incinerator for hazardous waste; (Foundation, 2014)

Rotary kiln incinerators are used to treat most forms of waste, such as solids, liquids, sludge and debris. The rotary kilns are cylindrical and rotate on its horizontal axis. The rotation rate of the kiln and residence time of solid waste are inversely related. Residence time for waste feed is varying between 30 to 80 minutes, by a rotation rate of 30 to 120 revolutions per hour and temperatures between 900 ºC to 1,200 ºC. (Lechner, 2004a)

Rotary kiln incinerators are designed with a co-current or counter current chamber. In the co-current design, waste is introduced at the burner end and flows down the rake, while the combustion gases are also drawn down the rake. In the counter current design, waste is introduced at the end opposite the burner and flows down the rake toward the burner, while combustion gases are drawn up the rake. Wastes are fed directly into the rotary kiln, either continuously or semi-continuously. (EPA, 1998)

The rotary kilns are possibly equipped with a secondary combustion chamber (afterburner) to destroy efficiently volatile organic contaminants. Off-gas from the kiln is routed through the afterburner and remains there one to three seconds at high temperature ranging from 900 ºC to 1,200 ºC. (EPA, 1998)

Land disposal systems

A landfill is a designed and constructed system to contain discarded waste in order to minimize releases of contaminants to the environment. Landfills are necessary if other hazardous waste management technologies like reduction, reuse or recycling cannot eliminate the generated waste. (LaGrega et al., 1994)

Landfills have to fulfil technical requirements in perspective of minimizing pollution from disposal. Requirements are:

- Double liner as protection for bordering ground
- Double leachate collection and removal system (LCSR)
- Leak detection system
- Run on, Runoff and wind dispersal controls
- Construction quality assurance
- Final cover (EPA, 2002)

After closing a landfill for hazardous waste following operations are intended:

- Continuing the double leachate collection and removal system
- Maintaining and monitoring the leak detection system
- Maintaining groundwater monitoring
- Prevention on storm water run on and runoff (EPA, 2002)

Solidification/Stabilisation treatment for hazardous waste

Cement-based stabilisation/solidification is applied worldwide for hazardous waste. The stabilisation/solidification has the aim to immobilize heavy metals, organic and inorganic compounds into a permanent matrix in cement and is suitable for inorganic waste materials. Another target is to change waste materials physically and chemically, that the risk of environmental pollution through leaching, erosion and dispersion will decrease. (Felix et al., 2001)

If cement is used as a binder for the stabilisation and solidification process, heavy metals can be fixed and are not leached out. Salts cannot be fixed into cement. If hazardous waste is implemented into a cement based stabilisation, it is sensitive for erosion due atmospheric influences also carbonation can have an effect. (Felix et al., 2001)

3.7 The Sagarmatha National Park and Buffer Zone

3.7.1 Administrative situation of the SNPBZ

Nepal is divided in five different development regions and 58 different municipalities. Each development region is zoned and divided in districts, municipalities and village development committees (VDC). The SNPBZ is situated in the eastern development region, in the Solukhumbu District.

The Solukhumbu District is divided into the Upper Khumbu, above Namche Bazar and Lower Khumbu, below Namche Bazar. The Sagarmatha National Park covers the area of the VDCs Namche, Khumjung and as the Buffer Zone to the National Park, Chaurikharka. The land utilization gives the first indication about the geographical characteristics of the Solukhumbu and hence the Sagarmatha National Park and Buffer Zone.

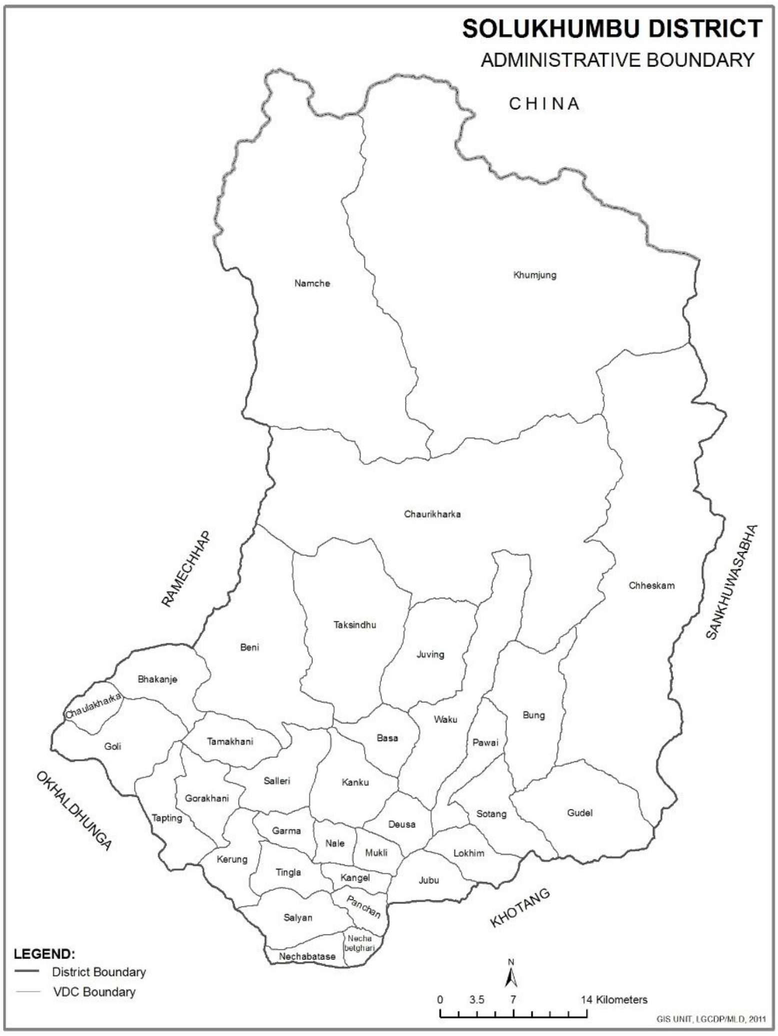


Figure 20: Map of the “Solukhumbu district” with administrative boundaries; (MFALD, 2011)

3.7.2 History of the SNPBZ

The region of the todays Sagarmatha National Park and Buffer Zone, was declared under the “National Park and Wildlife Conservation Act, 1973” as “area set aside for the conservation, management and utilization of flora, fauna and scenery along with the natural environment” (MSFC, 1973), on the 19th July of 1976 and is inscribed in the World Heritage List since 1979.

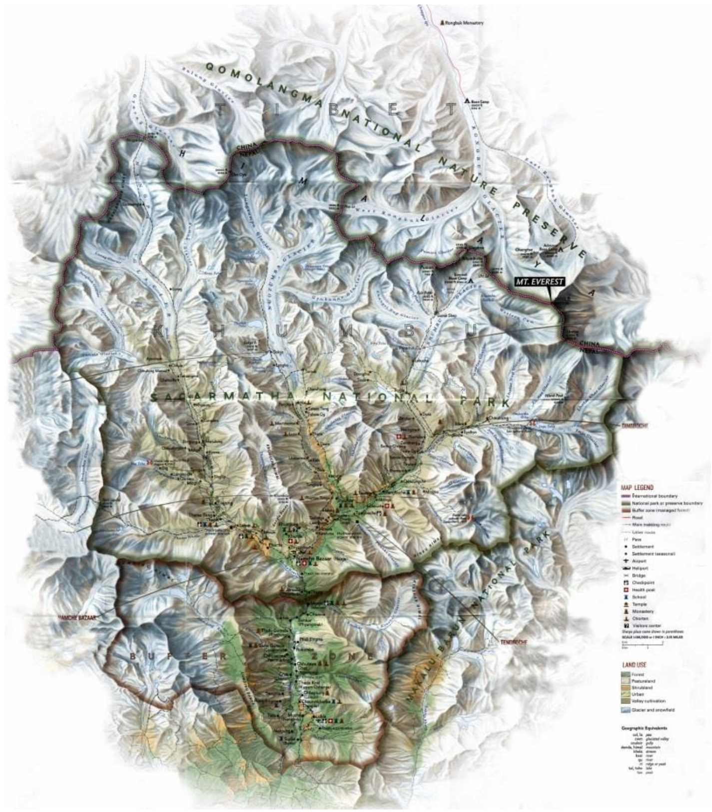


Figure 21: Map of the Sagarmatha national park and buffer zone; (S.N., 2014)

To enact the Sagarmatha region as a world heritage site, standards for national parks had to be significantly modified. These modifications in the standards for the national parks from the “Food and Agriculture Organization of the United Nations” (FAO) were necessary to harmonize the needs of the local Sherpa community, with the objectives to protect the wildlife, water and soil resources. (UNEP, 2008)

The park regulations do not apply to the settlements within the park, on the grounds that the Sherpa community determine their own lifestyle and are supposed to be guarded from adverse effects from tourism. At the same time catchments and their springs in the national park are from high value for the welfare of the people in Nepal and India as source for their water supplies. (UNEP, 2008)

3.7.3 **Geographical situation of the SNPBZ**

The national park area itself is departed into the national park, and its buffer zone, with a total size of 1,148 square kilometre (km²). Adjacent in the north is the “Autonomous Region of Tibet” with a nature reserve of the People´s Republic of China. In the western of the SNPBZ is the Gauri Shankar Conservation Area and in the eastern part is the

Makalu Barun National Park. (UNESCO, 2014) The southern border is defined with the district Headquarter Salleri.

Topography and the land-cover of the National Park stand at 69% of it is barren land above 5,000 m followed by grazing land with 28%. The smallest portion of the National Park is forested with 3%. All over the park are six different vegetation zones: lower subalpine, upper subalpine, lower alpine, upper alpine and subnival zone. (UNESCO, 2014)

Between the peaks of the highest mountain range in the world, are three main valleys, Nangpa, Gokyo and Imja. In the upper part of these valleys are glaciers which nourish the rivers Imja, from the Khumbu glaciers, Dudh Koshi from Ngozumpa glacier and Bhote Koshi which has its spring in Tibet.

The rivers coalesce further down to the Sun Koshi which flows down through the south east of Nepal and further on through India to the Golf of Bengal. (N. Ghimire, 2013)

According to GHIMIRE (2013), the water quality of the named rivers are fulfilling the World Health Organisation (WHO) and Nepali standards for drinking water except a few places. There had been changes in certain parameters in water bodies along the main trekking routes due inaccurate waste disposal and toilet conditions.

The main source for drinking water in villages is by spring or stream. The common toilet facilities are traditionally compost toilets in private households, lodges and hotels however also have compost toilets or constructed septic tanks for sewage disposal. (Shrestha, 2013)

3.7.4 **Climate conditions in the SNPBZ**

Focusing on the climate conditions, Namche Bazar was picked as the centre of the SNPBZ. The climate is semi-arid subtropical, with seasonal monsoon rains. (Joshi, 1982) The range of precipitation ranges from 733mm in Khumjung over 984 mm in Namche Bazar to 1,043 in Thyangboche, 80% of the named amount falls during the monsoon season between June and September. (Garrat, 1981) Regarding the temperature is the coldest month the January with an average of minus 0,4ºC.

In perspective on climate change the Himalaya struggle with the doubled speed of global warming, with a rise of 1ºC average air temperature since the mid-1970s. (Shrestha et al., 2005)

3.7.5 Legal framework within the SNPBZ with perspective on waste management

This chapter discusses the regulations and enactments out of the view of the National Park.

The difference between the nationwide regulations and the following legal regulations is that the legal matter is selected in view of the specific requirements of waste or more explicit hazardous waste management in an area with national park status in Nepal. The Acts, Regulations and Rules are valid within in the national borders of Nepal.

Local Self Governance Act and Rule 1999

This Act is providing an institutionalization of democracy to local bodies. Its aim is to integrate marginal groups into participation of a democratic state and equal development.

The act "constitutes local bodies for the development of the local self-governance system" (MOLJPA, 1999) and defines these local bodies first as "Village development committee". These committees are in duty to make programs for environmental, forest, vegetation and biological diversity, protection and against soil degradation. The wards are also responsible for an arrangement for disposal of wastes and to maintain sanitation within cities and in the area of accountability. (MOLJPA, 1999)

Municipalities have the duty to "carry out and manage or cause to be carried out and managed the acts of collection, transportation and disposal of garbage and solid wastes" (MOLJPA, 1999) and is allowed to impose service charges. It is forbidden by punishment to dump waste other than in the designated areas in the municipality. The punishment is a fine of up-to fifteen thousand rupees and the expenditures of the removal, to be paid from the causative person. (MOLJPA, 1999)

There is no explicit reference to hazardous waste within the act.

In the "Local Self Governance Rule 273(c) the provision of joint committee of local bodies within the Local Self Governance Rules", is established, that a local body can form a local body joint committee for environmental protection activities.

Under the Ruler Number 273 (c), burrows the provision for local body committees, to protect the environment and organise the waste management. (MOLJPA, 1999)

No further explanations in the direction of waste or hazardous waste are made.

National Parks and Wildlife Conservation Act, 1973

This act was publicized to promote a management and conservation for national parks as well wildlife and their habitat. On the basis of natural beauty and importance for the general public, the government of Nepal has the ability to declare an area as national park, reserve or conservation area, by publishing a notice in the Nepal Gazette. (MSFC, 1973)

The definition of a "national park" is: "an area set aside for the conservation, management and utilization of *flora, fauna* and scenery along with the natural environment". (MSFC, 1973)

The definition of a "buffer zone" is: "means a peripheral area of a national park or reserve prescribed under the "Section 3a" in order to provide facilities to use forest resources on a regular and beneficial basis for the local people". (MSFC, 1973)
To manage the tourism industry within a national park, the act states that the national park itself should provide hotels, lodges, public transport facilities by itself or through other parties by contract. Thirty till to fifty percent of the income of the national park should be reinvested, in co-operation with the local community, into the development of it.There are no further references to waste or hazardous waste. (MSFC, 1973)

Himalayan National Park Regulations, 1979

The regulations are based on the National Parks and Wildlife Conservation Act of1973. It regulates and prohibits several activities like, building, farming and cultivating of land also hunting and chasing of wildlife. The provision for entering the national parks is regulated for local and foreign visitors. In relation to waste, it is enacted that: "No one shall be allowed to produce waste or to throw waste within the park". (GOV, 1979)
Hazardous waste is not mentioned, but toxic substances: "Prohibition on throwing, putting or spraying the toxic substances : No person shall be allowed to throw any type of pesticides or chemical substances or narcotic or poisonous substances within the park or out of the park in such a way that making it to reach into the park or to put or spray in the river, springs or any other water resources flowing through the park or to put in any from [sic] by making it to reach into the park". (GOV, 1979)

Mountaineering Expedition Rules, 2002

The mountaineering rules had been framed by using the „Tourism Act 2035 (1978)". It manages the levy of the permit for mountaineering expeditions. It is prohibited to climb mountains in the Himalaya without any official permit. (GOV, 2002)

The climber is obligated to take a “Liaison Officer” on the expedition, who has the duties to control, conflict management and to act according the orders of the Government of Nepal. In reference to waste is “to carry the necessary work relating to environmental cleanness and garbage management”. A deposit for garbage management, of up to 4,000 US Dollar in the SNPBZ, is charged. (GOV, 2002)
According to the “Mountaineering Expedition Rules” the incidental waste has to be classified and managed according three different sorts and qualities;

“(a) Garbage which can be destroyed: Toilet paper, paper, cardboard, things made from bamboo, jute and cotton bag, decomposed food or….

(b) Garbage which can be recycled: Tin, bottle, jar, plastic can, plastic shit [sic], reusable gas cylinder, plastic bag or gas container.

(c) Garbage which has to be re-imported: Used oxygen bottle, used battery, equipment to be used for climbing or personnel goods etc”. (GOV, 2002)

Garbage, from the “Type A”, that can be destroyed has to be buried or destroyed under the control of a liaison officer or other representative of the Government of Nepal, so it has no adverse impact on environment. The garbage that can be recycled has to be brought to Kathmandu and handed over to an institution prescribed by the government of Nepal. The garbage according the “Type C” has to be brought back to the origin country. (GOV, 2002)
Hazardous waste can be found in the garbage of “Type B” and “Type C”.
During the field visit, there was no evidence of an export to Kathmandu for the recyclable garbage. Only a few goods like tin, gas cylinders and gas containers are recycled within the Sagarmatha National Park. A large burden is put upon the “Non-burnable dumps”, also garbage that is obligated to re-import can be found on dumps in the National Park.

Travel and Trekking Agency Rules, 2005

This rule was based upon the “Tourism Act” in order to provide for travel and trekking activities regulations.

Regarding environment and waste management; tourists and holders of the obligated visitors pass in national parks, are required by law to “burn or bury the goods used by themselves” and further in reference to the locality, “which has not belonged to the source of drinking water, religious place or place of public importance or place for public use/utility”. (MTCA, 2005)

There is no specific note or rule on hazardous waste.

Policy on Impact of Climate Change on World Heritage Properties 2008

The UNESCO organisation has brought out a publication about concern regarding world heritage site and the adverse impacts from climate change on “composition and distribution of natural, human and cultural ecosystems are expected to change as species and populations respond to the new conditions created by climate change”. (UNESCO, 2007)

The aim of the paper is to provide policy and decision makers a guidance to key issues dealing with climate change and how it could affect impacts in the sites. (UNESCO, 2007)

There is no specific reference about waste or hazardous waste.

3.7.6 Socio economic factors within the SNPBZ

Inhabitants

In the year 2011, the population census of Nepal recorded in the three VDCs of the SNPBZ a total of 7,161 inhabitants.

Table 4: Population the SNPBZ divided by VDCs (CBS, 2011)

VDCs	Total household	Total population	Male	Female
Chaurikharka	968	3,709	1,872	1,837
Namche	480	1,540	807	733
Khumjung	551	1,912	913	999
Total	1,999	7,161	3,592	3,569

Within the national park and its buffer zone are 48 settlements. The main settlements are Namche Bazar, Khumjung, Khunde, Thame, Thyangboche, Pangboche and Phortse.

Despite Chaurikhara having the highest population, it has the least number of settlements, followed by Namche and the VDC with the highest amount of settlements, Khumjung. (Shrestha, 2013) The Tibetan Buddhism is primary practised (Centre, 2014).

Infrastructure

There are no roads to or in the National Park, walking is the main type of transportation for goods in or out of the SNPBZ.

Between the villages in the national park the options for transportation are constrained to porters, mules and yaks. The only exceptions are rescue flights, medical maintenance and at high cost, the transport via helicopters.

Lukla is the main gateway to the National Park, where during the peaks of the tourist seasons, in average 17 flights are dispatched per day. In total about 2,000 flights are carried in the two main tourist seasons. (Luger, 2014) Lukla is the start and ending point for most tourists, expect for those who walk a trek from and to Jiri Bazar, the nearest road head, outside the national park.

The second landing stripe is situated between Namche Bazar and Khumjung. It is not operated for public passenger transportation. The onle expection are the guests at the Everest View Hotel. Still, SHRESTA (2013) describes it as useful for cargo and rescue flights.

Financial aspects within the SNPBZ

The main source of income are the tourism and agricultural sectors.(UNESCO, 2014) With the rising mountaineering and trekking tourism rates, a positive impact has been made on the regional economy. This was recorded and had a complex interplay of effects on the economic situation of locals and their livelihood and environment. (Daconto and Sherpa, 2010)

The living standards did increase, and the income source through tourism enabled higher education for children and health care facilities. Although it has to be mentioned that since there is no equal distribution of income inside the national park, the gap between richer and poorer people is getting bigger. (Shrestha, 2013)

Sherpa people had and have beside tourism their major income source through trading, livestock farming, with yaks, naks, crossbreeds and others and through traditional farming. (Shrestha, 2013)

There are a few industries working within the national borders like mineral water filling stations and weaving. (Shrestha, 2013)

Visitors and Climbers

Tourism in the region around the Mount Everest (Sagarmatha) started in 1950, when Nepal opened up for mountaineers and expeditions, since the year 1953, when Tenzing Norgay and Edmund Hillary successfully ascended the Mount Everest. With the year 2013, 6,871 mountaineers stood on top. (Hawley, 2014)

Climbers have to get a climbing permit and pay different amount of fees, equated to the height of the target peak. Smaller peaks have a reduced rate to bigger peaks. The permission for climbing has to be acquired from the government of Nepal, for peaks smaller than 7,000 meters the Nepal Mountaineering Association is in authority to levy the permission. (MTCA, 1981)

Because of the rising number of expeditions since the early 1950s, the tourism and trekkers inflow is also rising. According to the annual record from the SNPBZ information office, since 1998 to 2013, is an average rise of nearly 2%a year. In total numbers, the inflow for 1998 constituted 20,014 tourists, in 2013, 35,201 visitors had been recorded. (Rai, 2014)

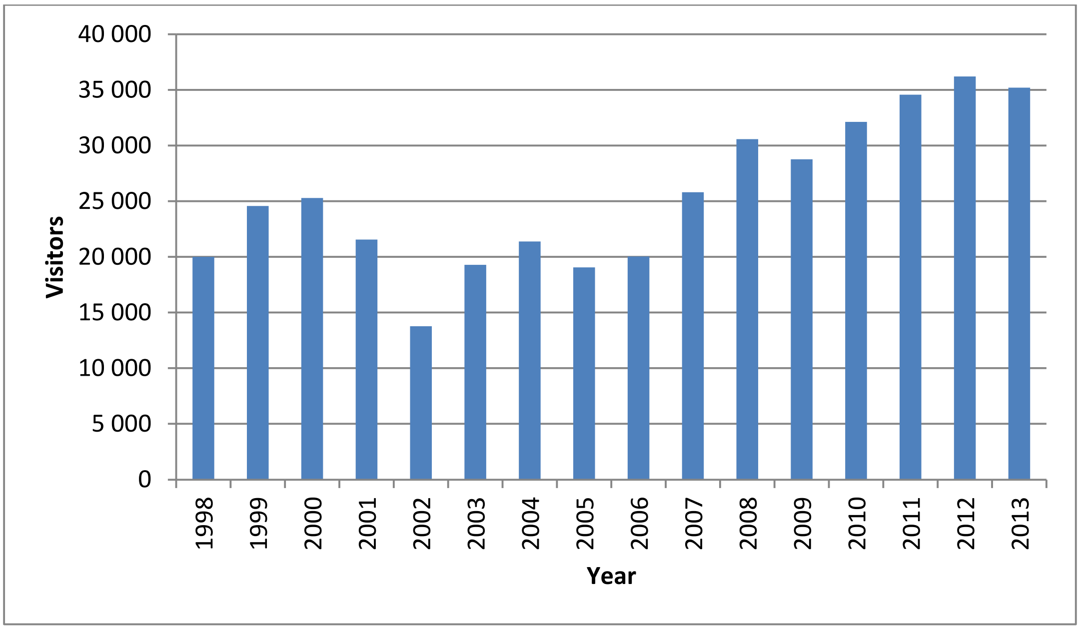


Figure 22: Annual record of visitors in SNPBZ, 1998 – 2013; (Kali Bahadur, 2014) (Own table)

There are two main seasons in the year, the first season is from March until May and the second and weaker season is between October and November.

The autumn season is the more popular time in the year. In these two months approximately 46% of the whole year's emergence of visitors are in the SNPBZ (Rai, 2014) while in the spring season in average 34% of the annually visitor stream is appearing. So together in four months nearly 80% of the annual tourism emerges.

Accommodation facilities

The number of accommodation facilities in the Sagarmatha and its Buffer Zone is about 450 lodges, according to SHRESTHA (2013) and steadily increasing. Without the Buffer zone, the number of lodges is 289 in the VDCs Namche and Khumjung. (Luger, 2011) The number of lodges increases annually.

3.8 Solid waste management in the SNPBZ

3.8.1 Goals and policies on waste management in the SNPBZ

The goals and policies that are formulated from the laws, regulations and rules mentioned in the former chapters, should be understood as an extraction out of the legal conditions adapted to local demands.

Since the National Park rules are not enforced in settlements, policies and goals for waste management in villages are touched circumferential by those. This means, the basement for the goals and policies are the national wide laws handling with waste management.

The goals on waste management in the SNPBZ are adhered in the “Solid Wastes Management National Policy, 2053 (1996)” and subdivided into three stages, combined into one hierarchy, the “3R – Concept”:

1) Reduce
2) Reuse
3) Recycle (MLD, 1996)

The most efficient way to encounter waste is to avoid the production. This avoidance is contained in the first stage of the “3R Concept”, in “Reduce”. Especially in the Sagarmatha National Park and Buffer Zone, reduction of waste is the most powerful lever against adverse environmental impacts based on waste. A reduction of imported goods which are prone to become waste, should be reconsidered to their necessity or exchanged to a more sustainable alternative.

Due the limited availability the Sagarmatha National Park is in a special situation regarding the balance between import and export of goods. As the main import of goods is processed by airplane to the park and the transport in the park by foot or hoof, the export of goods which becomes waste is not equal to their import. The national park has the problem to become a closed system in which geographical and economic constraints, inhibit a constant export of waste out of the national park. This is crucial in relation to hazardous waste.

The second stage, “Reuse”, is insignificant for the National Park and Buffer Zone. Regarding hazardous waste, a reuse option is elaborate or non- recyclable waste, obsolete.

Recycling, as the third aspired stage in the “3R-Concept”, is applied for aluminium cans (Zuser et al., 2011) which are melted and processed to souvenirs. Thermic recycling with the purpose of recovering energy wouldn´t be effective due high investment and maintaining costs. (Brunner and Fellner, 2007)

According to the non-governmental organization (NGO) “Eco Himal”, the aim is to enhance the “3R Concept” to a “4R-Concept” with the fourth stage “Rethink” (Sherpa, 2014), in which a prospective approach to waste management should provide adjusted solutions for the local demands.

What is not mentioned in the “3R/4R-Concept” is the most common way of treatment in the SNPBZ, the disposal through dumping. The two ways in which waste is dumped in the SNPBZ is treated, through burning, or untreated. It is also applied for hazardous waste.

3.8.2 Stakeholders of waste management in the SNPBZ

The stakeholders which are listed in the following are the decision makes and the concerned public. By gaining information on stakeholders, tailored public relation activities like trainings, or educations, as they are already taking places by the NGO ECO Himal are adaptable to specific demands. (ECO, 2014)

National and local legal authorities

(1) Government of Nepal

The stakeholders in this category are related the Nepalese government. The stakeholder here itself is the government, since it is the creator of the current and valid laws and responsible for their proper execution.

(2) Ministry of Culture Tourism and Civil Aviation (MCTA)

This ministry is one sporadic (Shrestha, 2013) financer of the solid waste management system in the SNPBZ.

(3) Nepal Mountaineering Association

This association organizes the permits for peaks under 7,000 meters. It is employed to levy the fees for the climbing permits. In its constitutions it has different references to environment and waste and is also a financer of the Sagarmatha Pollution Control Committee (SPCC).

(4) Sagarmatha national park, buffer zone management committee (SNPBZMC)

This committee is combined with the National Park management committee and the Buffer Zone management committee. Within the Buffer Zone management committee are Buffer Zone user committees hence groups. These Buffer Zone committees and groups are equally responsible for “keeping the environment clean”. (SPCC, 2012) The SNPBMC is working with the SPCC together and is supported financially.

(5) District Development Committee (DDC)

The DDC is a superordinate government agency from the Village Development Committee (VDC). The VDC is through the “Local Self Governance Act and Rule 1999” the first authority from the government in the national park and for this a stakeholder.

(6) Village Development Committee (VDC)

In the Sagarmatha National Park, the government is in the form of the local bodies; DDC and VDC, are not active in waste management except in allocating the revenues from the national park entrance fee, to the local bodies. It is not obligated that the allocated revenues are further distributed to waste management activities. (Zuser et al., 2011)

Private formal sector

(1) Sagarmatha Pollution Control Committee (SPCC)

The Sagarmatha Pollution Control Committee, is the major organization for activities relating with environment and especially waste in the Sagarmatha National Park. Legally registered under the District Administration Office and the Social Welfare Council, it was founded in the year 1991 from the people of Solukhumbu in association with the World Wide Fund for Nature (WWF). The SPCC is the main actor for waste management and future projects regarding sustainable waste management approaches. (SPCC, 2014) In reference to hazardous waste, the SPCC is the protagonist for collection, treatment and disposal. Income source for waste management is generated through waste fees which are levied by the SPCC itself. (Zuser et al., 2011)

(2) Ice fall doctors

The Icefall Doctors are a group of Sherpas who belong to the SPCC. Their task is to maintain and prepare the route through the Khumbu icefall for Mount Everest aspirants. The major income for the SPCC is generated by the Icefall Doctors. (SPCC, 2014)

(3) Trekking Agencies Association Nepal (TAAN)

The TAAN is also according to SHRESTA (2013), a major stakeholder in the SNPBZ. Its main task is to form an umbrella organization for the trekking agencies in Nepal and promote mountain tourism. Beside their economic objectives, environmental activities are also in the agenda. (TAAN, 2014) The TAAN is a stakeholder for the waste management and it’s financing in the SNPBZ.

(4) Everest Summiteers Association (ESA)

The Summiteers Association has in its objectives, to save and promote environmental protection of Mount Everest. Cleaning up and further activities related with waste are executed to fulfil the set goals. (ESA, 2014)

(5) Social clubs

Women and youth clubs are major stakeholders not only for waste management in the SNPBZ, but respectively for the village community. Women’s clubs are also in charge of the collection of waste fees or waste from SPCC in order to relieve the committee on labour costs and lack of employees. (Zuser et al., 2011)

Private informal sector

Adverse to other regions in Nepal, no scavengers or waste pickers haven been observed during the field wok of this thesis.

Non-governmental organisation (NGO)

EcoHimal: This NGO has been involved for twenty years in different activities in the Himalayan region. It is focused on working in cooperation with local initiatives and communities, on economic, social, cultural and environmental questions. It is the main NGO which supports the SPCC in their work in general and in specific on waste management and initiator of the “Saving Mount Everest” report 2011. (ECO, 2014)

Service users

(1) Inhabitants

Local residents are service users of the existing waste management system and also organize their waste management for themselves. The separation is allocated by who is running a business and through that is served by the SPCC and who is forced to organize their own waste management. (Zuser et al., 2011) Beside this circumstance it is also possible to bring waste from private households to waste management facilities, which are prosecuted by the SPCC and are charged with waste fees. Since the concentration of businessesare in Lukla and Namche Bazar, the self-organized waste management is found outside of these villages.

(2) Business owners

Business owners are counted as retail traders, tea shop conductors and lodge owners. These businesses are mainly served by the SPCC staff in Lukla and Namche Bazar.

Retail traders are a special interest in this study because these are major importers of goods which become hazardous waste. Lodge and teahouse owners are also prominent generators of solid waste and further hazardous waste.

(3) Visitors

The visitors of the SNPBZ are also a major group of stakeholders for waste management but difficult to involve into any evolutionary process for waste management. In respect to hazardous waste, the role of visitors will be illuminated in this study later on.

(4) Hospitals

Hospitals are in addition to business owners, a source for hazardous waste. The importance of health facilities in the waste management, are so far not reviewed and will be also investigated in this study.

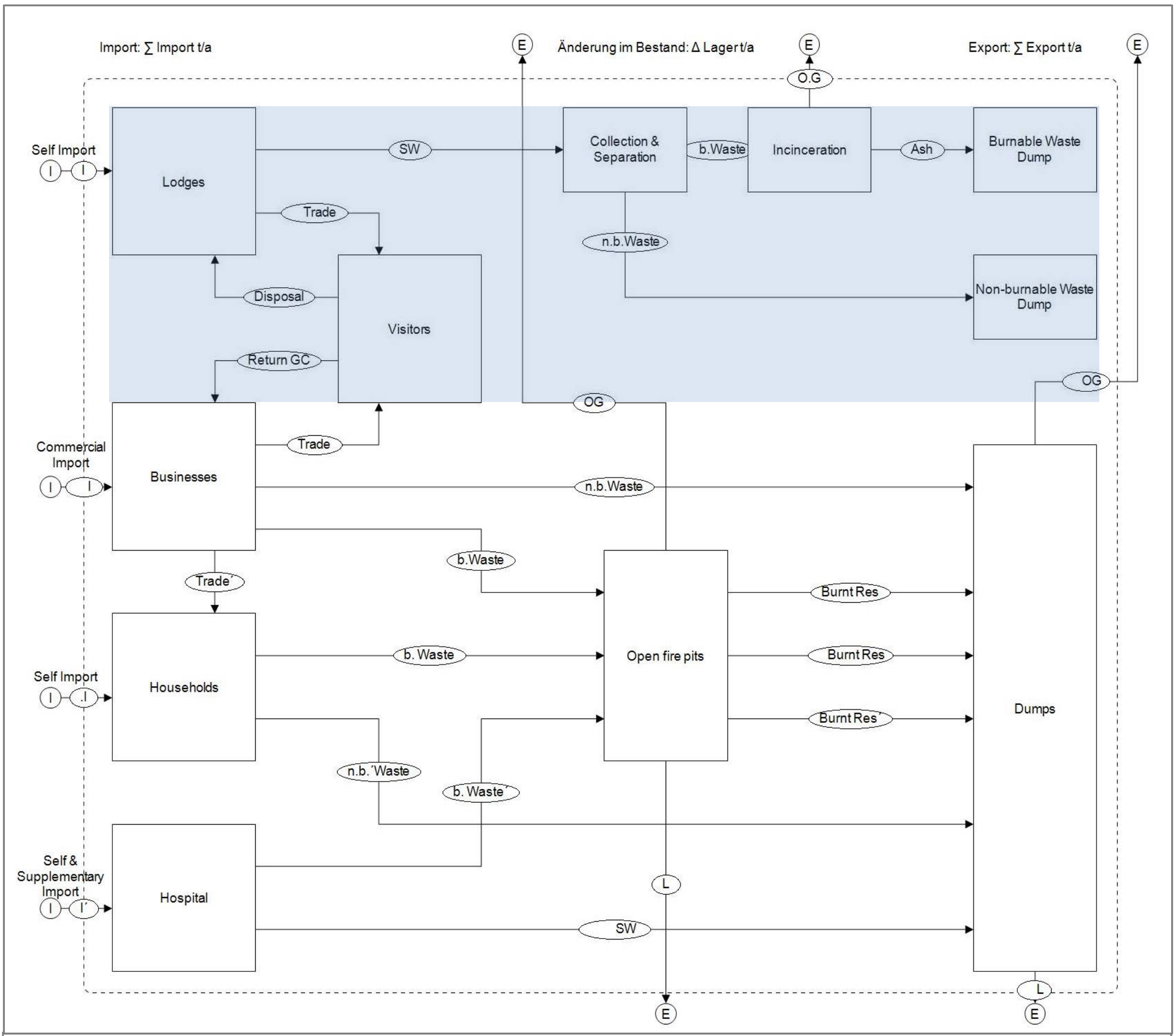
The enumeration of stakeholders is a snap-shot of a situation, and for that an attempt of completeness in view of the management of hazardous waste. It can be extended or abbreviated in dependence of the current question.

4. Results

4.1 Contemporary general solid waste management in the SNPBZ

To detect the co-treated hazardous waste within the solid waste stream, information on pathways, collection and, composition of general solid waste in the SNPBZ are demanded.

Pathways, collection and treatment of solid waste



Legend:

(b. Waste) burnable Waste, (Burnt Res) Burnt Residues, (E) Export, (I) Import, (L) Leachate, (n.b. Waste) non-burnable Waste, (OG) Off Gas, (SW) Solid Waste, (Trade) Trading with goods, (Return GC) Return of unused Gas Cartridges, SPCC serviced Waste Management

Figure 23: MFA for "Scenario 0"; (Own figure)

The composition of the general waste stream in the SNPBZ is at the source different to the collected solid waste stream in this thesis. The composition at the source of the waste stream has share of 79% biodegradable waste (PATHAK, 2011), which is used for fodder. This value of biodegradable waste equates the average amount in Asian developing countries. (AZNI et al., 2014) The remaining 21% departs itself into the investigated fractions in this thesis. The solid waste management in the SNPBZ is conducted by the SPCC which covers approximately 60% of the total produced waste.

4.1.1 Collection system for solid waste management

The collection system in the SNPBZ is subdivided into:

(1) Curb-side collection
(2) Deliver - system

The curb-side collection is provided for business owners, lodges and private household owners against annual waste fees. Waste collectors from the SPCC pick up the waste directly from the service users and bring the collected waste to the incinerators.

The deliver-system is for private households which bring their waste directly to the incinerators. The deliver-system is mainly applied for the near surroundings of the incinerators in Lukla and Namche Bazar.

Through both collection systems, hazardous waste is treated at waste treatment plants.

On average, annually 205,700 kg of solid waste are collected. The collected and delivered waste is separated at the incinerators into a burnable and non-burnable waste fraction. Approximately 80% are burnable and 20% are non-burnable waste. Burnable waste is discarded, paper, plastic and partly residues. Non-burnable waste is metal, glass, and partly residues. The ash from the burnable waste is dumped separately from the untreated non-burnable waste. Focus from the SPCC is the tourism sector, with waste fees paid lodges.

Figure 24: Current form of burnable-waste treatment; (Own figure)

Beside the existing SPCC waste management between Lukla and Namche Bazar, private households, business owners and hospitals are dumping their waste open or burn it at open fire pits. Above in Namche Bazar and in the Gokyovalleys mainly Women's and Youth-clubs or other community based organizations take up the task of providing a waste management system. (Shahi and Shrestha, 2013)

Figure 25: Open fire pit in Namche Bazar; (Own figure)

Major producing groups for solid waste in the SNPBZ are the residents and visitors. On average, 25,520 visitors are staying about 10 days per year. Residents are counted with 7,161 persons who are stay permanently for 275 days a year with a 90 days absence during the winter.

The number of annual visitors and permanent living residence is rising. This presupposes:

1) The amount of solid waste is rising
2) The hazardous waste load is also rising.

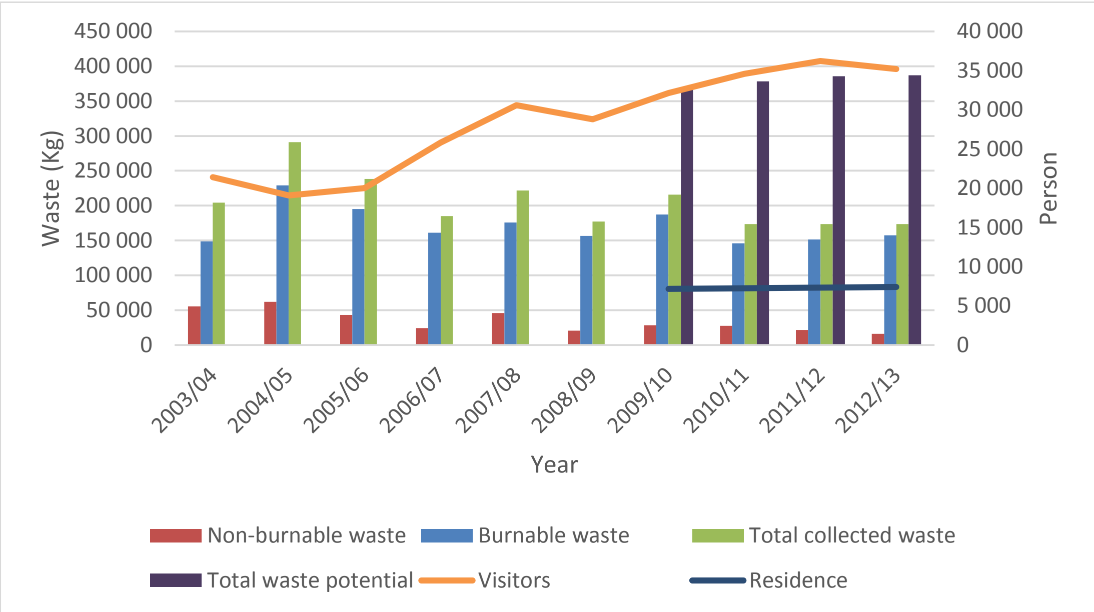


Figure 26: Collected waste in major settlements in contrast to population numbers;(CBS, 2011) (Kali Bahadur, 2014; Zuser et al., 2011) (Shahi and Shrestha, 2013) (Own figure)

The total collected waste is decreasing, while the visitor number is rising and the residence number remains stable. The burnable and non-burnable waste fraction confers to the total collected waste generated and is also decreasing.

4.1.2 Composition of solid waste at incinerators

The composition of the collected waste is as followed:

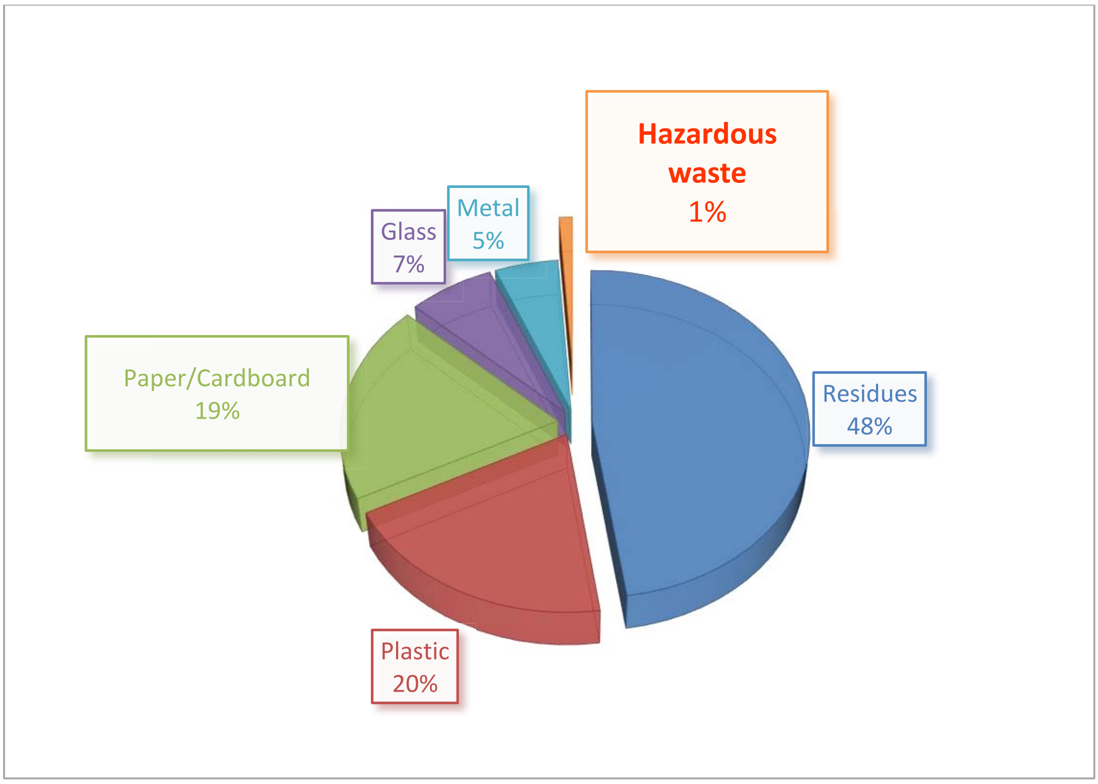


Figure 27: Annual waste composition in the SNPBZ; (Own figure)

The sorting to the overarching fractions "Burnable waste" and "Non-burnable waste" are done by hand from the SPCC staff, impurities are probable.

Table 26: Results from sorting analysis at incinerators in Lukla and Namche Bazar (Own table)

Location	Inci-nerator (No.)	Fractions (%)					
		Plastic	Paper/ Card-board	Metal	Glass	Resi-dues	Hazardous waste
Lukla Namche	1 1	19 21	16 23	4 6	11 3	50 45	0 2
Total	2						
Average share (%)		20	20	5	7	48	1

"Plastic", "Paper/Cardboard" and parts of "Residues" are burnt. "Metal", "Glass", "Hazardous" waste and parts of "Residues" are unburnt. "Hazardous" waste in Lukla was 0,45%, under one percent. Namche Bazar, is the biggest village in the SNPBZ and has a share of 1,65 percentage of hazardous waste. The transport costs for porters are partly responsible for the increased percentage of "Plastic", "Paper/Carboard" and "Metal".

The quantified 1% of hazardous waste are counted on the assumed total waste composition.

4.1.3 Composition of solid waste at dumps

Dumped waste departs itself:

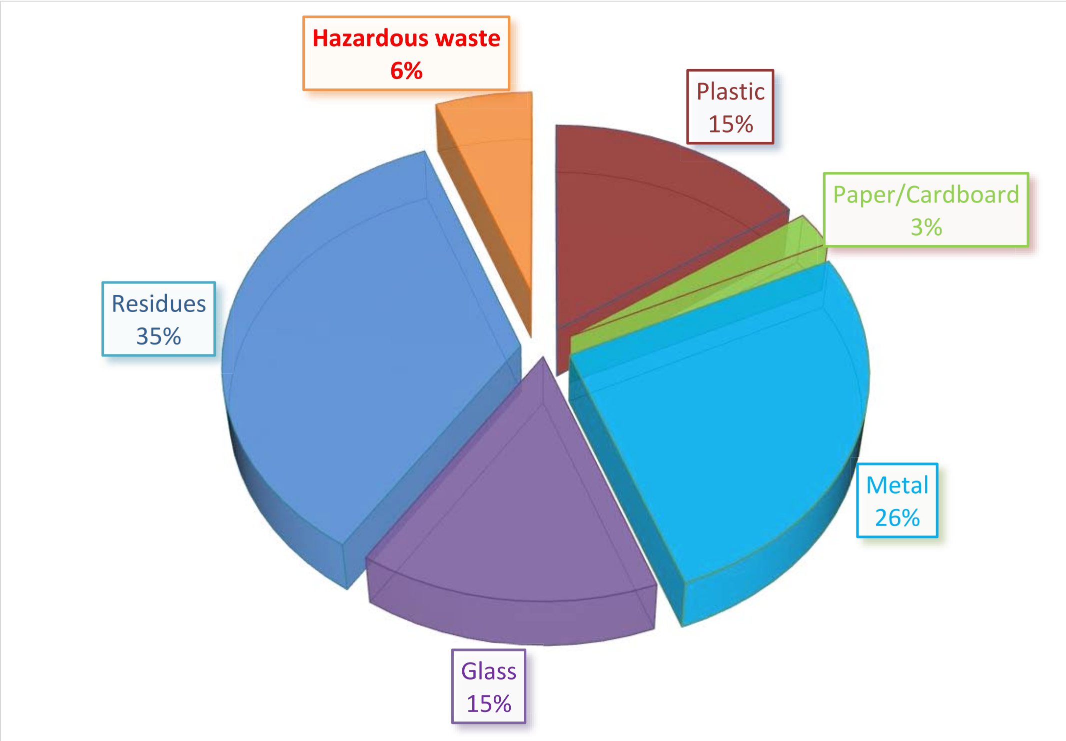


Figure 28: Waste composition on dumps; (Own figure)

The hazardous waste percentage is higher at the dumps than at the conducted incinerator waste samplings. Dumps are used over years and hazardous waste appears accumulated at the dumps. Dumps which are associated with the tourism industries have a higher percentage of hazardous waste than dumps only used by residents. The boundary line between tourism influenced and residents influenced dumps are floating. There seems to be no influence factor like distance or height on the occurrence of hazardous waste.

Figure 29: Dump for burnable waste in Namche Bazar; (Own figure)

Plastic is mainly dumped in the lower regions like Lukla, Dokdingma and Tawa. “Paper/Cardboard” is burnt or used as a fire starter in the households. The percentage of the “Metal” fraction rises with altitude and distance to Lukla while the “Glass” fraction is decreasing.

Table 27: Results from sorting analysis at dumps in the area Lukla and Namche Bazar (Own table)

Location	Dumps (No.)	Fractions (%)					
		Plastic	Paper/ Card-board	Metal	Glass	Resi-dues	Hazardous waste
Lukla	4	19	0	10	35	34	2
Dokdingma, Tawa	2	23	8	35	18	15	1
Namche Bazar	4	3	0	30	4	45	18
Kumhjung	3	16	2	30	4	46	2
Total	13						
Average share (%)		15	3	26	15	35	6

Each dump which was investigated showed a typical character. The dumps with the highest share of hazardous waste were in Namche Bazar. Reason are, the collected gas cartridges from Everest Clean ups go to only one dump. Namche Bazar, the biggest village and the village with the highest agglomeration of tourism facilities, produces the maximum quantity of hazardous waste in the SNPBZ. In Lukla, the dumps with the highest share of hazardous waste are associated with the incinerator and situated near the hospital with open fire pits. Kumhjung, was in taken into the investigated dumps to have a reference out of the investigated scope.

4.2 Hazardous waste in the contemporary solid waste management

Hazardous waste is found in the solid waste stream in the SNPBZ, and presently not treated separately. The aggregated hazardous waste from expeditions are not subject of this thesis, although in quotation of the legal situation, every expedition is in charge to transport their waste back to Kathmandu valley.

4.2.1 Potential sources for hazardous waste

As main sources for hazardous waste, the following can be detected:

(1) Business owners

Business owners are the eminent source for hazardous waste. In this category every store who is selling hazardous waste vulnerable goods is counted, e.g.: Shops for electronic devices, souvenirs or daily supplies. These businesses are the main gateway for hazardous waste used by residents and visitors and do not offer a take back system for hazardous waste items. Retail business owners are the biggest importers for hazardous waste also and not examined in specific as waste producers. Businesses are not vastly hazardous waste producer and mainly served by the SPCC. What kind of items which may cause hazardous waste will be described in the later chapter. It is estimated that the number of businesses is increasing with the increase of the visitors and residents.

(2) Hospitals

Hospitals are not examined either as hazardous waste producers but it is for certain, that most waste produced in small hospitals like in the SNPBZ are hazardous due its infectious attributes. This hazardous waste is defined as “medical healthcare waste”. There is no data about how much waste is produced daily or is imported by the hospitals. The hospitals are not served by the SPCC or any community based organization, so medical healthcare waste is treated by the hospital medical staff. There are no designated treatment facilities for this kind of hazardous waste. The advent of medical healthcare waste is small in comparison with the total waste but with the most harmful characteristics in the SNPBZ. Hospitals are mainly visited by residents, while visitors or mountaineers are brought out in most cases to

Kathmandu. Currently there are two hospitals active in the SNPBZ, the “Lukla Hospital” (Hospital, 2014) and the “Kunde Hospital.” (Trust, 2014) Besides this two major hospitals are several smaller health care facilities active also with unknown input or output streams.

(3) Mountaineers

Mountaineers are not counted in this enumeration and the official visitor statistics. By reason that they are integrated into expedition groups for which are a different legal framework for waste is valid, the import or export of hazardous waste was excluded from this thesis. Produced hazardous waste has yet to be officially exported back to Kathmandu.

(4) Residents

The inhabitants of the SNPBZ, are involved in generating hazardous waste due to their self-import of hazardous waste vulnerable goods, which are needed for daily life. The self-import is estimated as low with also a low potential for savings. Residents and households who are not involved in the tourism industry, have a comparatively sparse and non-material intensive living standard. Most of the residents and households who are involved into tourism are along the main trekking route, served directly by the SPCC or at least supported through the SPCC. Beside the tourism sector, most residents are not involved into an official waste management system and have to manage the aggregated hazardous waste by themselves. As the number of residents is slightly increasing, this may imply also a slight increase in total generated waste and through that, a slight increase in hazardous.

(5) Tourism industry

In this category lodges, teahouses, restaurants and other tourism facilities are summarised. The tourism industry is directly and indirectly the main producer of hazardous waste. This is done directly, through using and disposing hazardous waste vulnerable products, and indirectly through the maintenance of the tourism facilities and the day-to-day operations. During the trekking season hazardous waste from visitors is disposed in accommodation facilities and in the off-season or lower touristic season due renovating and maintenance on the accommodation facilities hazardous waste is generated. Most tourism facilities along the main trekking route between Lukla and Namche Bazar are served by the SPCC. The number of accommodation facilities has been rising since the beginning of commercial tourism since the 1970s. For example Namche Bazar, the most populated village in the SNPBZ, has a rising infrastructure for visitors and residence and has to cope with different negative environmental impacts. (Pawson et al., 1984)

(6) Visitors

This group of waste producers are incorporated within the tourism industry in the SNPBZ and are the trigger for the major part of produced waste. The visitor stream is rising although the amount of waste is decreasing. Visitors themselves can be appraised as ecology-minded. Most visitors are aware of negative impacts through their visit. Indubitably this appraisal is to be valued as valiant. An occurrence which illustrates the hidden production of hazardous waste is the decreasing use of batteries through porters. Before porters used their cell phones for their amusement during work, battery-powered portable stereo system where used which had been attached to the carried loads. Since cell phones replaced the portable stereos the demand and the uncontrolled disposal for batteries has decreased. (Sherpa, 2014) Beside porters there are also guides for individuals or groups not counted in the visitor statistics. There is no data about the import or export of hazardous waste vulnerable goods from visitors.

4.2.2 Typical hazardous waste components

The following hazardous waste components had been detected during the field visit, the enumeration is in alphabetic order:

(1) Batteries

Basel Convention, Annex VIII, List A, A1010,”Metal and metal-bearing waste”,

Basel Convention, Annex VIII, List A, A1160, “Waste lead-acid batteries, whole or crushed”.

Figure 30: Discarded batteries in dumped waste; (Own figure)

(2) Compact fluorescent light bulbs:

Basel Convention, Annex VIII, List A, A1010,”Metal and metal-bearing waste”.

Figure 31: Broken compact fluorescent light bulb in dumped waste; (Own figure)

(3) Gas cartridges:

Basel Convention, Annex III, UN-Class 1, Code: H3, Characteristics: Flammable liquids.

Figure 32: Discarded gas cartridge in dumped waste; (Own figure)

(4) Infusion bags

Basel Convention, Annex VIII, List A, A4020, “Clinical and related wastes; that is wastes arising from medical, nursing, dental, veterinary, or similar practices, and wastes generated in hospitals or other facilities during the investigation or treatment of patients, or research projects”.

Figure 33: Dumped infusion bags and needles; (Own figure)

(5) Injections

Basel Convention, Annex VIII, List A, A4020, “Clinical and related wastes; that is wastes arising from medical, nursing, dental, veterinary, or similar practices, and wastes generated in hospitals or other facilities during the investigation or treatment of patients, or research projects”.

Figure 34: Clinical waste containing needles and medicaments; (Own figure)

(6) Lubricant cans

Basel Convention, Annex VIII, List A, A3, A3020, “Waste mineral oils unfit for their originally intended use.”

Figure 35: Discarded lubricant can on dump; (Own figure)

(7) Medicaments

Basel Convention, Annex VIII, List A, A4020, “Clinical and related wastes; that is wastes arising from medical, nursing, dental, veterinary, or similar practices, and wastes generated in hospitals or other facilities during the investigation or treatment of patients, or research projects”.

(8) Paint cans

Basel Convention, Annex VIII, List A, A1010, ”Metal and metal-bearing waste”,

Basel Convention, Annex III, UN-Class 1, Code: H3, Characteristics: Flammable liquids.

Figure 36: Led containing paint can used as plant pot; (Own figure)

4.2.3 Quantities of hazardous waste generated within the solid waste

With a value of 1% of hazardous waste in total waste, the resultant table illustrates the annual production of hazardous waste in dependency on the annual total waste.

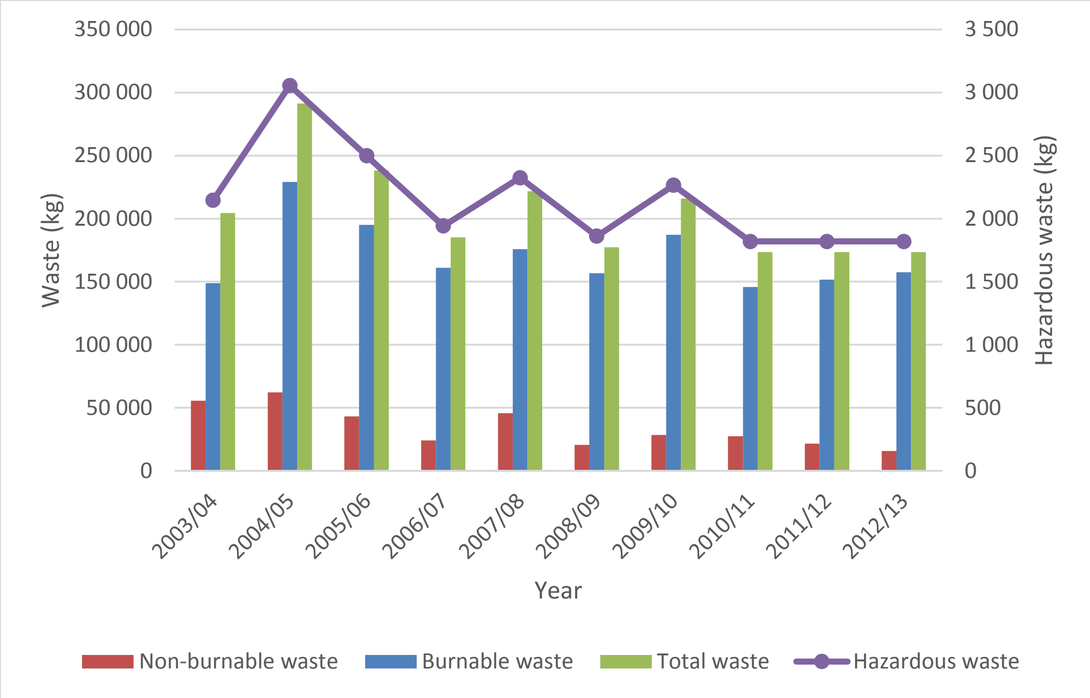


Figure 37: Total and hazardous waste production in the SNPBZ; (Shahi and Shrestha, 2013) (Own figure)

Annually, in average are 2,100 kg of hazardous waste discarded, co-treated and dumped with the non-burnable waste stream.

4.2.4 Co- disposal of hazardous with solid waste

After the sorting and the treatment processes, the disposal of ash and unburnt trash is put on the dump. The appearances of the dumps range from an excavated dump to widespread, ground levelled dumps. There are no engineered barriers, leachate collection or treatment system between the earth surface and the dumped waste. Ground levelled and excavated dumps commonly have stone walls for enhancing the volume. The dumps are barely fenced in and are accessibly by cattle or birds.

SPCC operated dumps are divided into dumps for burnable waste, where ash of the incinerator is dumped and non-burnable waste dumps, where the collected and unburnt waste is dumped. Hazardous waste is mainly found in the non-burnable waste dumps.

Dumps which are not served by the SPCC are open for the public and mainly used by residents. These dumps have open fire pits for treatment or the dumps get fired in irregular intervals. Hazardous waste also can be found here.

Figure 38: Example for an open dumping near Namche Bazar; (Own figure)

4.2.5 Leachate from co-dumped hazardous waste

The burnable waste is dumped already separated after the incineration process and the non-burnable waste which contains the hazardous waste is dumped without incineration.

Through the average high particle size of metal and glass and the composition out of plastic, paper and residues, a small share of humidity is supposed. Infiltrating water in the dumps may percolate unhampered through the waste body and enables to mobilize soluble contaminants and their entry into the circumfluent soil and water bodies.

Investigated heavy metals are Mercury (Hg), Cadmium (Cd), Manganese (Mn), Nickel (Ni), Lead (Pb) and Zinc (Zn).

Table 28: Average data on seasonal waste advent, leachate production and heavy metal discharge (Karnchanawong and Limpiteeprakan, 2009)(Own table)

Non-burnable waste (kg/a)	35,000
Leachate (l/a)	30,000
Heavy metal discharge (g/a)	300

On average a heavy metal load of approximately 300 g are discharged in the monsoon season from the SPCC serviced non-burnable waste dumps. Discharged loads from public dumps are not included in these calculations. It can expected that the heavy metal discharges on dumps which are not served by the SPCC resemble to the calculated values.

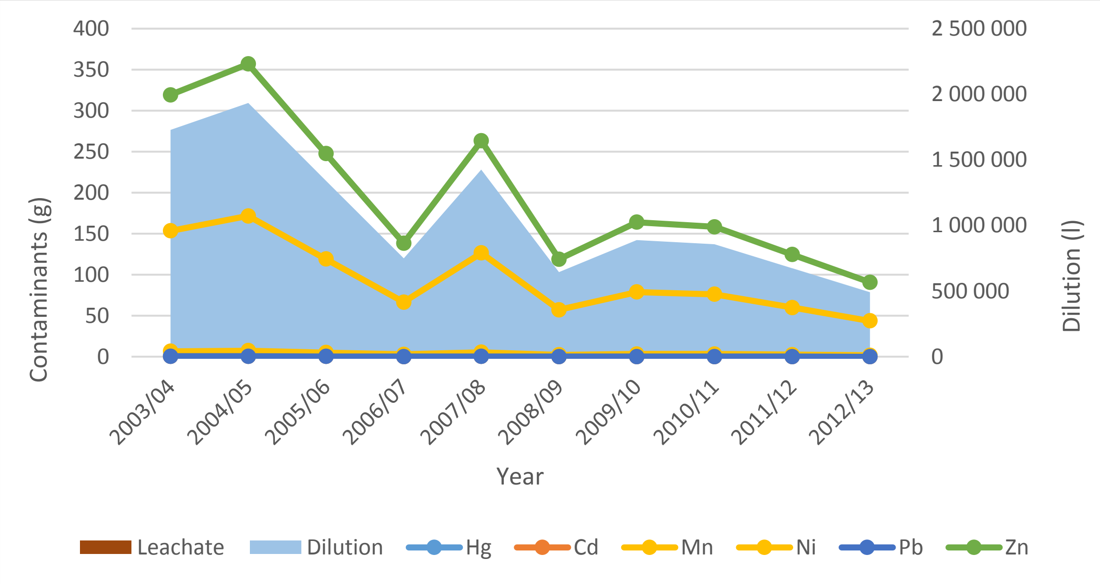


Figure 39: Seasonal share of discharged heavy metals in leachate and its dilution; (Karnchanawong and Limpiteeprakan, 2009)(Own figure)

On average Zinc is the primary contaminant with a share of 67% followed by Manganese with 32% and Nickel with 1% on the total heavy metal discharge. Other contaminants like Mercury, Cadmium and Lead, have a limited and nearly equal share in the leachate.

To provide the WHO-recommended drinking water standards, a dilution of the leachate is calculated. 1,000,000 litres of fresh water are needed to dilute the produced leachate from the SPCC served non-burnable waste dumps. This quantity of fresh water represents three times the average annual water withdrawal for a Nepalese inhabitant. (FAO, 2014)

4.3 Expenditures and revenues for contemporary solid waste management

There are six income sources for the SPCC which runs waste management in the SNPBZ:

(1) Everest Summiteers Association (ESA)
(2) Ministry of Culture, Tourism and Civil Aviation (MTCA)
(3) Nepal Mountaineering Association (NMA)
(4) Sagarmatha National Park, Buffer Zone Management Committee (SNPBZMC)
(5) Trekking Agencies Association Nepal (TAAN)
(6) Village Development Committee (VDC)

Together with the SPCC, the ESA, MTCA, NMA and TAAN an assessment committee is formed which is concerned with the amount of the icefall route fee for climbers. This fee amounts in the spring season to about 500 $ (51,000 Rs) per climber and 25,000 $ (2,500,000 Rs) per expedition in the autumn season. The amount of the fee indirectly influences the income source for waste management, since the SPCC has to depart its revenues to several projects beside the waste management. The incomes from the icefall rout fee is for the SPCC the major income source for running the solid waste management. (Shrestha, 2013)

Further income sources are the Village Development Committees from Khumjung and Namche VDC, which allocated 600,000 Rs (6,000 $) in the fiscal year 2009/2010 and Namche VDC allocated 300,000 Rs (3,000 $) in the fiscal year 2010/2011. The SPCC is not constantly receiving an equal amount if financial support from each VDC. (SPCC, 2012)

An income source for the waste management is the annual door-to-door waste fee collection from lodges, ranging from 1,500 Rs (15 $) to 6,000 Rs (60 $) and households, 100 Rs (1$), in Lukla and Namche Bazar conducted. The waste fee is calculated according to the size of the lodge. Between Lukla and Namche Bazar, the local Woman's Club assumes the collection of the waste fee. (Shahi and Shrestha, 2013)

The revenues from the entrance fee of 3,000 Rs (30 $) per visitor, is half provided for the community development in which a part is reserved for waste management.

Counterpart of the income sources are the expenditures for the existing waste management in the SNPBZ. Accounts under expenditures are:

(1) Street sweeping in the villages
(2) Waste picking on trails
(3) Waste collection
(4) Waste treatment
(5) Waste disposal
(6) Waste dumping
(7) Maintain existing waste facilities
(8) General management.

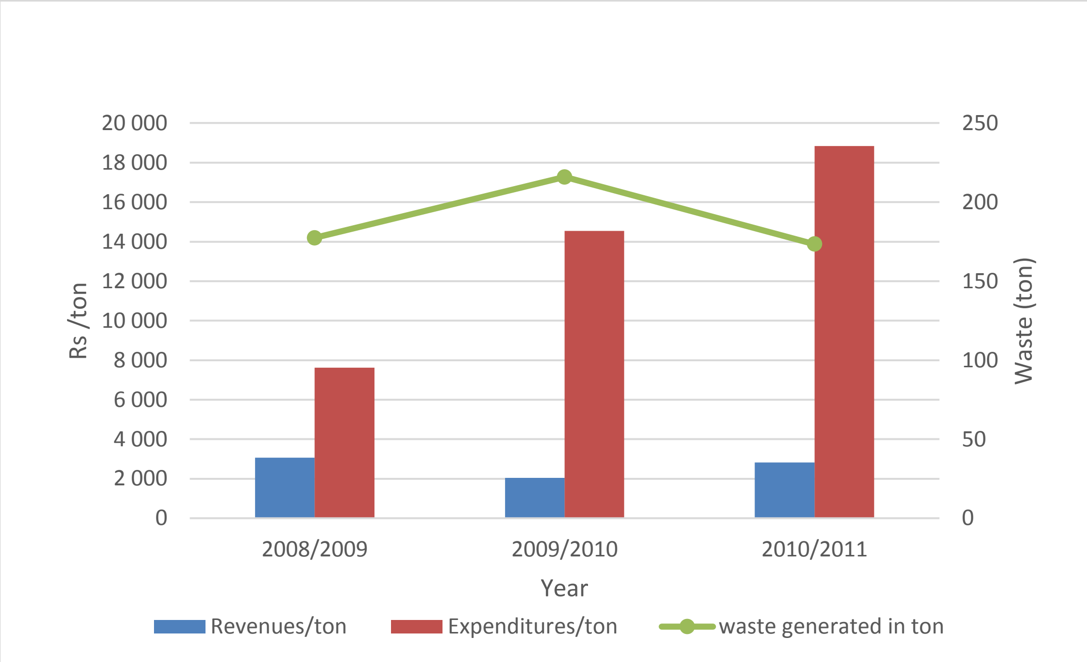


Figure 40: Comparison revenues and expenditures per ton and year; (Shahi and Shrestha, 2013) (Own figure)

Average expenditures and revenues broken down per ton show an imbalance from 2,600 Rs (26$) for revenues and 14,000 Rs (140) for expenditures. (Shahi and Shrestha, 2013) The regular average marginal return of revenues on expenditures is 23%. The SPCC as has nearly five times more budget for a ton waste as the average municipality (ADB, 2013)in Nepal. In the fiscal years 2009/2010 to 2010/2011 the average expenditures per ton of waste had increased with 23% while the general waste collection decreased with 24%. There is no obvious reason for the rise of expenditures.

Calculated waste fee

The calculated waste fee for covering all expenditures is 66 Rs for residents, which is covered by the SPCC waste management.

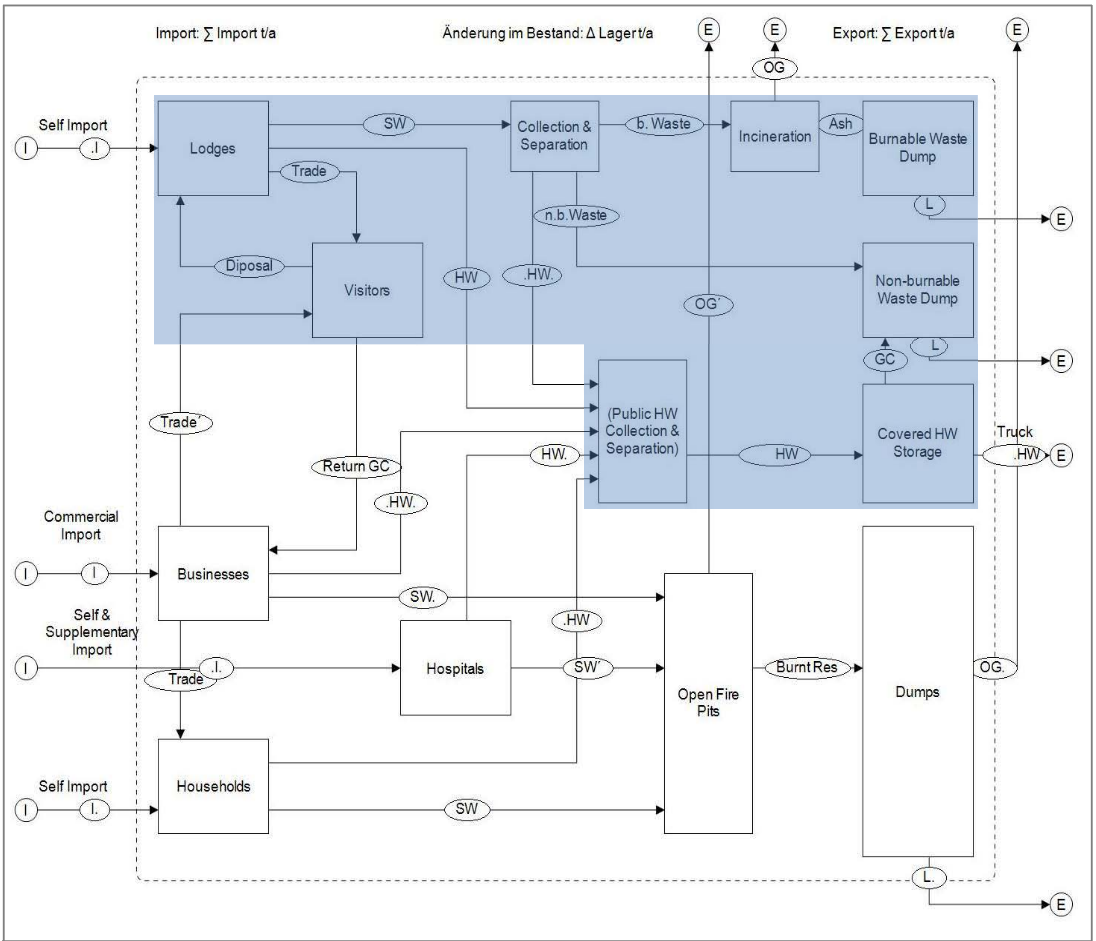
5. Scenarios

5.1 Scenario 0: Business as usual

The “Scenario 0: Business as usual” is the contemporary applied solid waste management. Quantities for hazardous waste, leachate, dilution and costs remain on status quo. No changes are conducted.

5.2 Scenario 1: Collection and long-term storage with export by trucks

Situation



Legend:

(b. Waste) burnable Waste, (Burnt Res) Burnt Residues, (E) Export, (GC) Empty Gas Cartridges, (HW) Hazardous Waste, (I) Import, (L) Leachate, (n.b. Waste) non-burnable Waste, (OG) Off Gas, (SW) Solid Waste, (Trade) Trading with goods, (Return GC) Return of unused Gas Cartridges, SPCC serviced Waste Management

Figure 41: MFA for Scenario 1; (Own figure)

Beside the implemented and served waste management from the SPCC, a hazardous waste collection system is established. Five years is the estimated time until the road to Lukla will be finished and hazardous waste may be exported out of the SNPBZ to appropriated treatment/ disposal facilities.

This hazardous waste collection system is a combination of a delivery and collection system. To provide a working hazardous waste service without additional staff to the “Scenario 0”, are bins in the village of Namche Bazar and Lukla installed. These bins offer three different copartments, for batteries, CFls and one for general hazardos waste e.g.: small electronic devices.

The bins are provided for the public with the focus on tourism related facilities like lodges. At lodges are small vessels provided in which visitors and tourism related staff, e.g. porters, may dispose small hazardous waste items.

Bins that are installed at the incinerators in Lukla and Namche Bazar are only for impurities which are sorted out while dividing the total waste stream into the burnable and non burnbale waste fraction.

Hospitals are urged to separate potential hazardous waste at the source. For this, closeable vessels are prearranged by the hospital itself. The non-hazrdous waste fraction is treated furthermore with open fire pits on open dumps. The hospital staff is in charge to bring full vessel with hazardous waste directly to the centralized hazardous waste storages.

Private households and business owners are also covered with the public hazardous waste bins.

The hazardous waste storage centre is located in Lukla, in reason for the future connection to the road. The storage is a basin made out of of concrete with four separated compartments. The basin of approximatly 270 ft² is at ground level and covered by a roof. In each compartment of approximatly 70 ft², one hazardous waste fraction is disposed separated from another (Harather, 2013). Compartments are for batteries, CFLs, health care vessels and general hazardous waste items like small electronic devices. Through an elevated doorstep to each compartment an user friendly loading and unloading is ensured. The arrangement of the compartments, with a total volume of 1,600 ft³, are designed for the catchment of five years.

After five years of storing hazardous waste in Lukla, the export is done by truck. In five years approimatly 11,000 kg of hazardous waste are stored. The calculated costs for the transport of the waste include the transport of the collected HW and the price for transporting for the distance Lukla to Kathmandu.

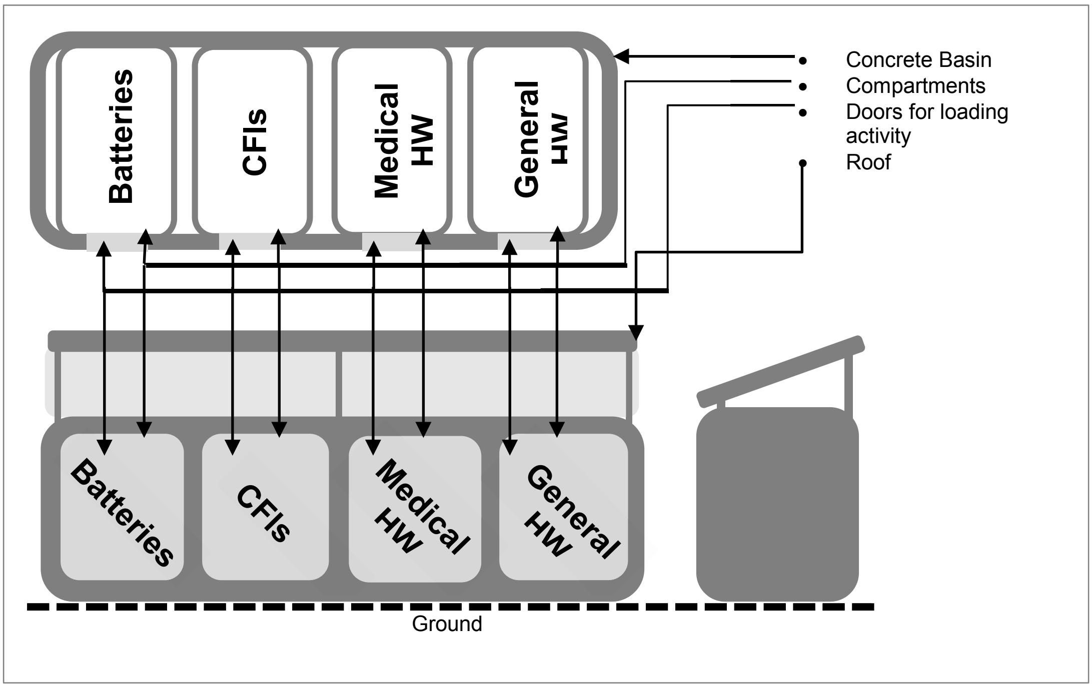


Figure 42: Ground, front and side layout of hazardous waste storage site; (Own figure)

Consequences

Inhabitants and visitors are able to dispose of hazardous waste in public accessible waste bins which are provided by the SPCC. Through a public disposal service at the lodges, the separated, captured hazardous waste, has a high achievement level of collecting the emerged HW in the SNPBZ is given.

By separating hazardous waste at the source, the SPCC staff is not involved in a sorting process with harmful hazardous waste items. The delivered closable vessels from the hospital are the key to a safe handling with health care waste.

At the central storage unit each compartment is sealed through their concrete bordering so an unintentional mixture between hazardous waste fractions is avoided. The roof covers the compartments from atmospheric precipitation and other weather related influences. Through the exterior walls from the concrete basin cattle and other animals are restrained.

The roof covers the compartments from atmospheric precipitation and other weather related influences. In order of circumventing any leachate production, the covered hazardous waste is the key to controlled leachate production. If the whole, simulated, amount of batteries is collected and stored, the leachate production of approximatly

30,000 litres and 300 grams of heavy meals is immobilised. This leads to a saving of 1,000,000 litres of fresh water for dilution.

Concerning CFLs, positive effects are accomplished by collecting discarded CFLs and storing them on a controlled site. Where possible, influences on the environment are disrupted through the controlled deposition of hazardous waste items. The exclusion of atmospheric precipitation leads to an immobilisation of heavy metals within in the compartment. The release of air pollutants, a non-preventable task of handling and extended hazardous waste management would lead to further investments in adequate disposal sites.

Discarded gas cartridges are stored temporarily in the hazardous waste site. With the manual release of the remaining gas out of the gas cartridges, the emptied cartridges are safe to dispose on non-burnable waste dumps. With the release of gas out of nearly empty gas cartridge, the consequence of conducting greenhouse active gas into the atmosphere is connected. The positive effect is the ability of disposing non-explosive cartridges.

Over the intake of medical waste in closed vessels, the outtake of hazardous waste from open dumps, potential harmful and infectious material is secured. The closed vessels guarantee a hygienic and safe handling for the serving hospital staff in the first, and the SPCC staff in the second place. With the general hazardous waste collection, like small electronic devices, the potential in-tray of heavy metals in the environment of the SNPBZ is dodged.

The connection to the road in Lukla, is a cost-efficient way of transport for hazardous waste out of the SNPBZ. The positive impacts on this scenario will be shown in the later comparison between the scenarios.

Financial aspects

“Scenario 1” is calculated with the amount of five years and without transportation costs for construction materials from Kathmandu to Lukla.

Calculated over five years, total annual costs of approximately 270,000 Rs (2,600 $) are required for realising the hazardous waste collection, storage and export by truck. For construction the covered storage site approximately 773,000 Rs (7,700 $) are demanded.

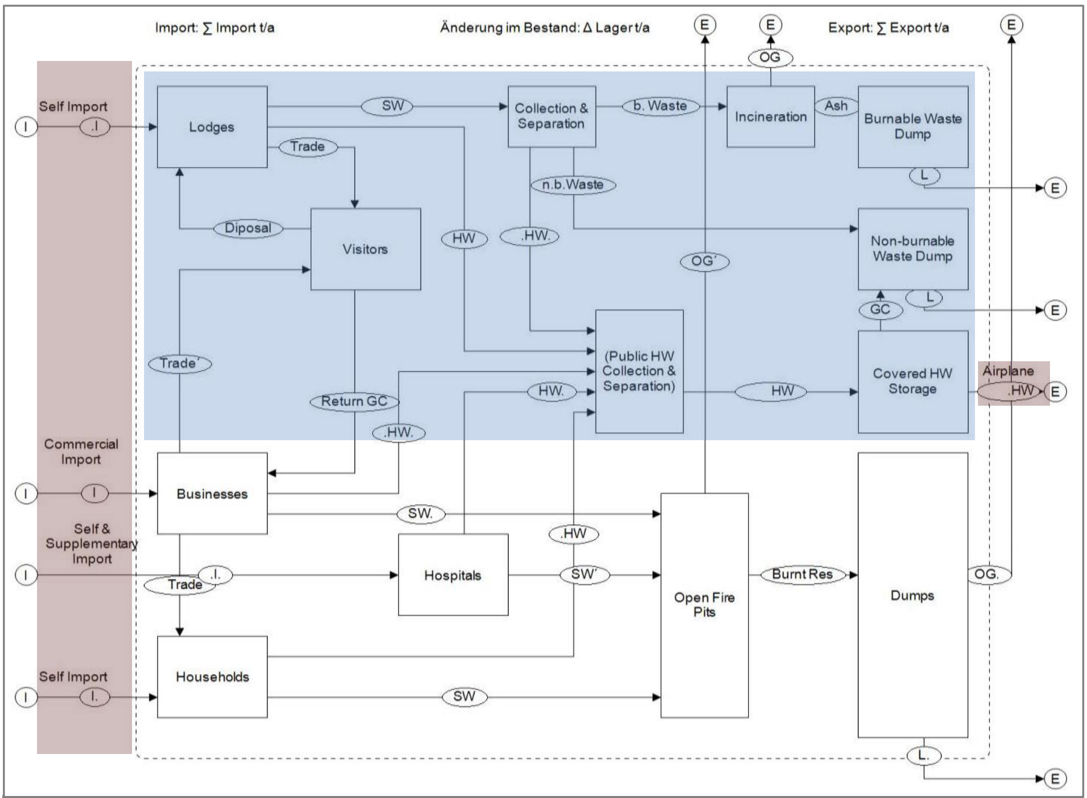
The total costs for transportation is approximately 74,000 Rs (7,400 $) for porters and 110,000 Rs (1,100 $) for the truck export after five years storing approximately of 11,000 kg of hazardous waste.

A new staff member for the SPCC is employed for the tourist season which is in total five months, calculated with the Nepalese average work wage, ends up in a 17,000 Rs (170 $).

The hazardous waste fee for this scenario is 7 Rs per capita/month/residence. Cumulated with the waste fee for the solid waste management, a total waste fee of 73 Rs (0,7$) is demanded.

5.2.1 Scenario 2: Collection, storage and annual export by plane

Situation



Legend:

(b. Waste) burnable Waste, (Burnt Res) Burnt Residues, (E) Export, (GC) Empty Gas Cartridges, (HW) Hazardous Waste, (I) Import, (L) Leachate, (n.b. Waste) non-burnable Waste, (OG) Off Gas, (SW) Solid Waste, (Trade) Trading with goods, (Return GC) Return of unused Gas

Figure 43: MFA for Scenario 2; (Own figure)

This scenario has the aim of an annual exporting of the collected hazardous waste to an appropriate recycling/disposal plant in Kathmandu by plane. This means the total export of possible contaminants out of the sensitive ecosystem of the SNPBZ.

At the start of the “Collection, storage and annual export scenario”, is the collection of hazardous waste. The collection is conducted, like described in “Scenario 1”. A deliver system and a parallel conducted curb side collection is implemented. The deliver-system is established through public accessible bins for hazardous waste items and over the opportunity for health care establishments to bring closable vessels for their emerged hazardous waste. The curb side collection provides, for the already present waste fee paying tourist facilities, a door-to-door collection of hazardous waste. Condition for the acceptance of hazardous waste at the collection centre, is the separated collection of hazardous waste items at source. So the service providing staff has as little as possible contact with potential harmful contaminates.

Hazardous waste items in the collected solid waste stream, is sort out.

While the “Scenario 1”-storage may take up the amount of hazardous waste of five years, the covered storage here covers only the amount of one year and is emptied and exported. This storage site of approximately 50 ft², is divided in four compartments. The location for the covered storage is in Lukla where there is an available airport.

To gain detailed information on products which may come to an end as hazardous waste and are imported into the SNPBZ, a governmental control unit would need to be installed in Lukla. The same control unit is on duty to record the export of hazardous waste out of the SNPBZ. At this control point, every importer of hazardous waste vulnerable goods, is encouraged to place the hazardous waste vulnerable goods, e.g.: batteries, CFLs, gas cartridges, paints on record. Based on these records, an annual import - export balance is created. With the help of the import-export balance, losses of the hazardous waste management are detected and provides information for further hazardous waste management planning’s.

The export itself in this scenario is conducted by airplane on behalf of the SPCC and brought in the first place to Kathmandu. Calculations are focusing on the transport from Lukla to Kathmandu.

Consequences

Residents and visitors are covered by a hazardous waste collection system that is accessible for residents through public hazardous waste bins and for the tourism sector through a door-to-door collection conducted by the SPCC. Through the hazardous waste collection no hazardous waste in the major settlements is disposed on dumps. This leads to a vast reduction of contaminants in-tray into the environment of the SNPBZ from open dumped hazardous waste.

The centralised hazardous waste storage with roofed and sealed compartments, contribute a separated and safe collection of different hazardous waste fractions. Through the barring of atmospheric precipitation, the leachate production is avoided which saves at least 1,000,000 litres of freshwater from dodged leachate.

The hospitals role in hygienic and safety is separating hazardous waste in closable vessels at source. Solid waste which arises at the hospitals is burnt at the open fire pits and dumped.

The dilution of potential CFLs leachate is not taken into account; also the emissions from the emptying process from gas cartridges are not counted.

A main consequence is the complete annual export of hazardous waste out of the SNPBZ. In controlling the hazardous waste export out of the SNPBZ, the government has also the duty to form a legal definition on hazardous waste.

Financial aspects

"Scenario 2" is calculated with five years and without transportation costs for construction materials from Kathmandu to Lukla.

Calculated over five years, total annual costs of approximately 260,000 Rs (2,600 $) are required for realising the hazardous waste collection, storage and export by airplane. For construction the covered storage site approximately 160,000 RS (1,600 $) are demanded.

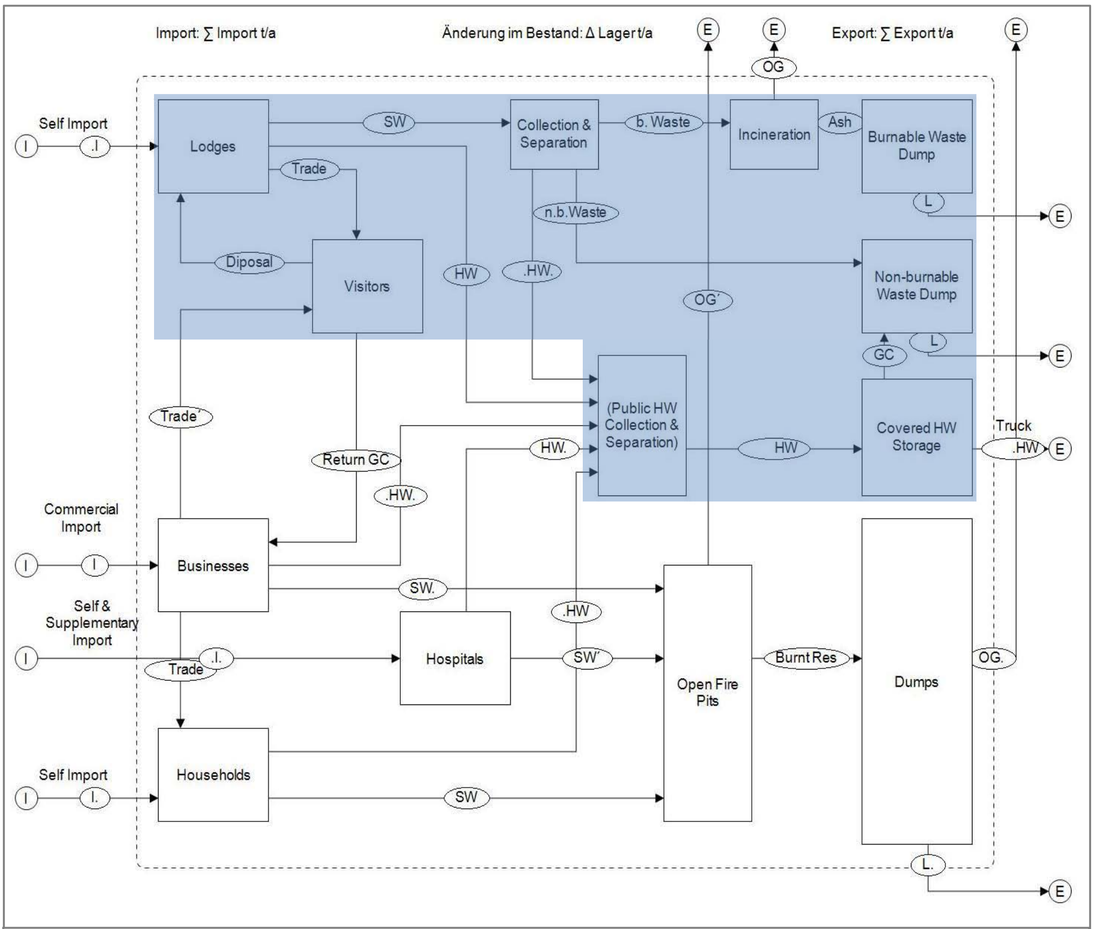
The total costs for transportation mounts in approximately 74,000 Rs (7,400 $) for porters and 140,000 Rs (1,400 $) for the annual airplane export of 2,100 kg of hazardous waste.

A new staff member for the SPCC is employed for the tourist season which is in total five months, calculated with the Nepalese average work wage, ends up in a 17,000 Rs (170 $).

The hazardous waste fee for this scenario is 7 Rs per capita/month/residence. Accumulated with the waste fee for the solid waste management, a total waste fee 60 Rs (0,6$) is demanded.

5.2.2 Scenario 3: Road connection to Lukla under the perspective of hazardous waste

Situation



Legend:

(b. Waste) burnable Waste, (Burnt Res) Burnt Residues, (E) Export, (GC) Empty Gas Cartridges, (HW) Hazardous Waste, (I) Import, (L) Leachate, (n.b. Waste) non-burnable Waste, (OG) Off Gas, (SW) Solid Waste, (Trade) Trading with goods, (Return GC) Return of unused Gas Cartridges, SPCC serviced Waste Management

Figure 44: MFA for Scenario 3; (Own figure)

The third scenario illuminates the consequences if Lukla, and therefore the SNPBZ, is connected to a tarmac road. An increase of visitors and demand on daily supplies is possible. A change with consumption patterns from residence are likely (Sangam, 2014). The transport of goods is drastically increasing due the decreasing prizes for goods and the resulting increased demands.

The characteristics in this scenario are determined, with an increased waste emergence from 0,155 to 0,376 kg/day/residence, which is the average waste production for a Nepalese inhabitant. The number on visitors and their waste production, with 0,204 kg/d/capita, and composition are kept the same to “Scenario 0: Business as usual.”

The treatment and disposal facilities are same as in “Scenario 1”. The collection is conducted by the SPCC, public bins for hazardous waste and door-to-door collection.

Consequences

Through the increment at the inhabitant's waste production, the total annual waste production rises from approximately 470,000 to 793,000 kg of waste. Supposing that the waste composition, with a HW share of 1%, stays the same, hazardous waste will increase from 2,100 kg to 8,300 kg. A result of the increased HW, the leachate also rises from approximately 30,000 up to 102,000 litres which needs a total amount of approximately 4,000,000 litres for diluting heavy metals. With the implementation of the HW-management like in "Scenario1", this increased leachate production is avoided by the collection of the total emerged hazardous waste.

If there is no adaption in the current general waste system, as described in "Scenario 0", the SPCC is able to treat and dispose approximately 30% of the overall produced waste, in the SNPBZ.

Financial aspects

Calculated over five years, the annual costs are approximately 512,000 Rs (5,100 $). Therefore the minimum size of the storage for the annual HW amount hast to be 210 ft², which causes construction costs of approximately 600,000 Rs (6,000 $).

The total costs for transportation mounts in approximately 292,000 Rs (292,000 $) for porters and 83,000 Rs (8,300 $) for the annual truck export of 8,300 kg of hazardous waste.

With these expenditures, 26% of the general waste in the SNPBZ is collected, treated and disposed or respectively exported by the SPCC.

A new staff member for the SPCC is employed for the tourist season which is in total five months, calculated with the Nepalese average work wage, ends up in a 17,000 Rs (170 $).

The future hazardous waste fee increases to a monthly 30 Rs (0,3$) for 4,375 residents. The cumulated waste fee for the solid waste management and the hazardous waste management is 96 Rs (0,96$).

5.3 Assessment of HW management scenarios

A final conclusion with the synced financial and environmental perspective is given.

Environmental aspects

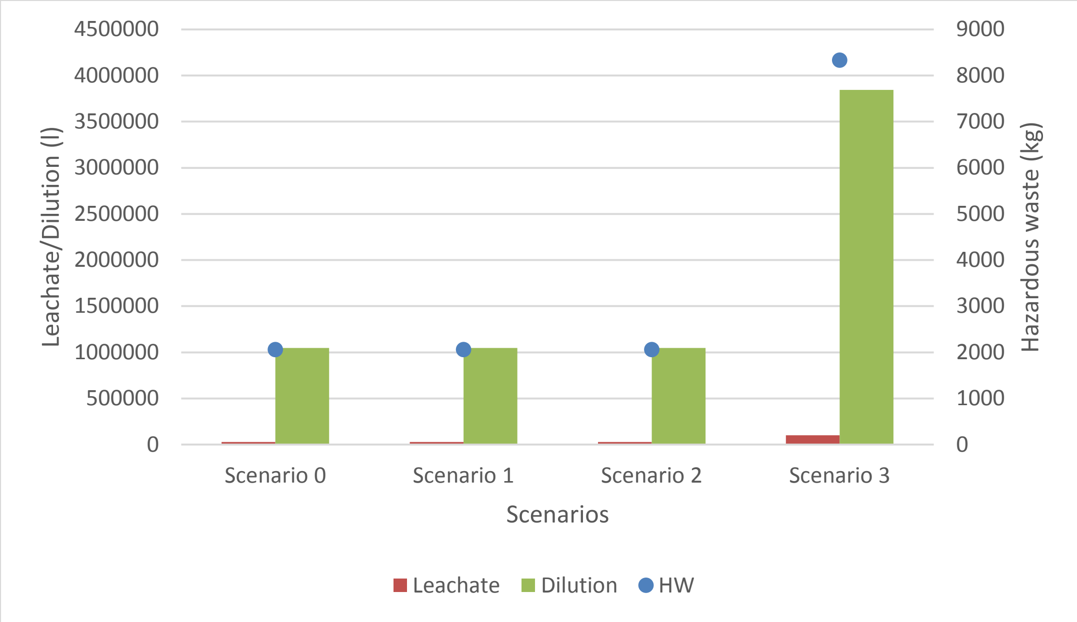


Figure 45: Environmental assessment of scenarios; (Karnchanawong and Limpiteeprakan, 2009) (WHO, 2008) (Own figure)

Summarising the environmental perspective in the scenario, “Scenario 0: Business as usual” it represents the consequences on leachate and dilution with the presumption of having 1% hazardous waste in the solid waste. The dilution of the leachate to achieve WHO drinking water standards in “Scenario 0” is the highest. Approximately 38 times the amount of the leachate is needed for dilution. This rate of dilution shows also the high impact factor of contaminants within the produced leachate.

The share of the annual hazardous waste is with approximately 2,100 kg, for “Scenario 0”, “Scenario 1” and “Scenario 2” the same. In “Scenario 3”, the HW share rises to 8,300 kg. Through implementing a HW management, the leachate production is avoided. Consequence is the stopped demand on freshwater for dilution since no leachate is emitted into the environment. Expect “Scenario 0”, every scenario implies a hazardous waste management which safes over a million litres of fresh water each year. Heavy metals are captured within the HW storage and are not accumulated in the environment of the SNPBZ.

Financial aspect

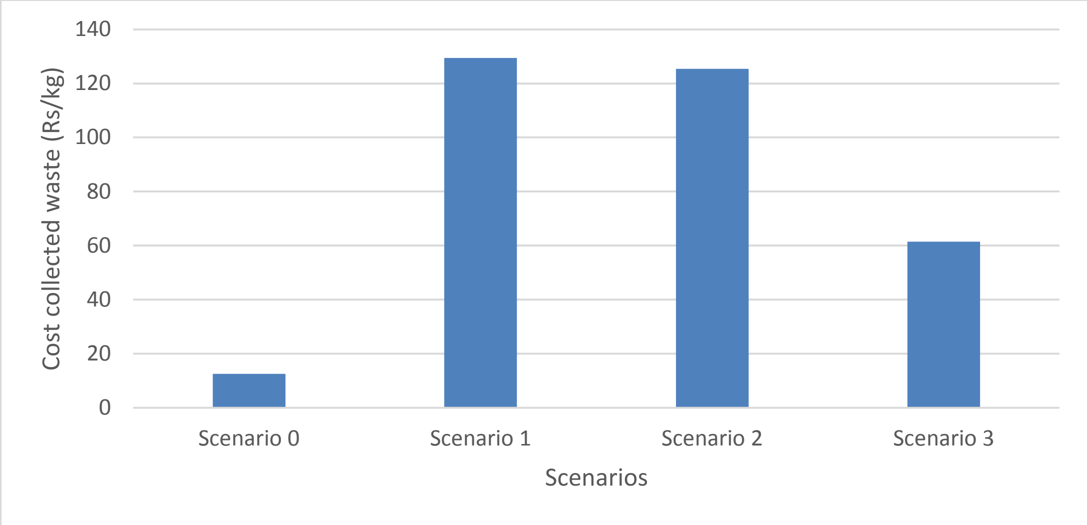


Figure 46: Financial assessment for scenarios in Rs per collected kg waste; (Own figure)

The “Scenario 0: Business as usual” is the current applied scenario for the general waste and is the cheapest scenario. Hazardous waste is treated in mixture with general waste. No investments into collection, construction or export are applied.

The “Scenario 1: Collection and long-term storage with export of hazardous waste by trucks” is the most expensive scenario. Highest cost driver in the “Scenario 1” is the construction of the hazardous waste storage for five years.

“Scenario 2: Collection, storage and annual export of hazardous waste by plane” deals with the specific of having modest entry costs lying under the “Scenario 1”, with the construction of a HW storage for one year. Highest cost driver is the annual export by plane.

“Scenario 3: Road connection to Lukla under the perspective of hazardous waste” is the third expensive scenario and deals with the possible impacts on the hazardous waste management if Lukla is connected to the road. Highest cost factor here is the again the construction of the hazardous waste storage for the increased hazardous waste emergence. The annual truck export makes this scenario the second cheapest after “Scenario 0”.

Combined comparison of scenarios

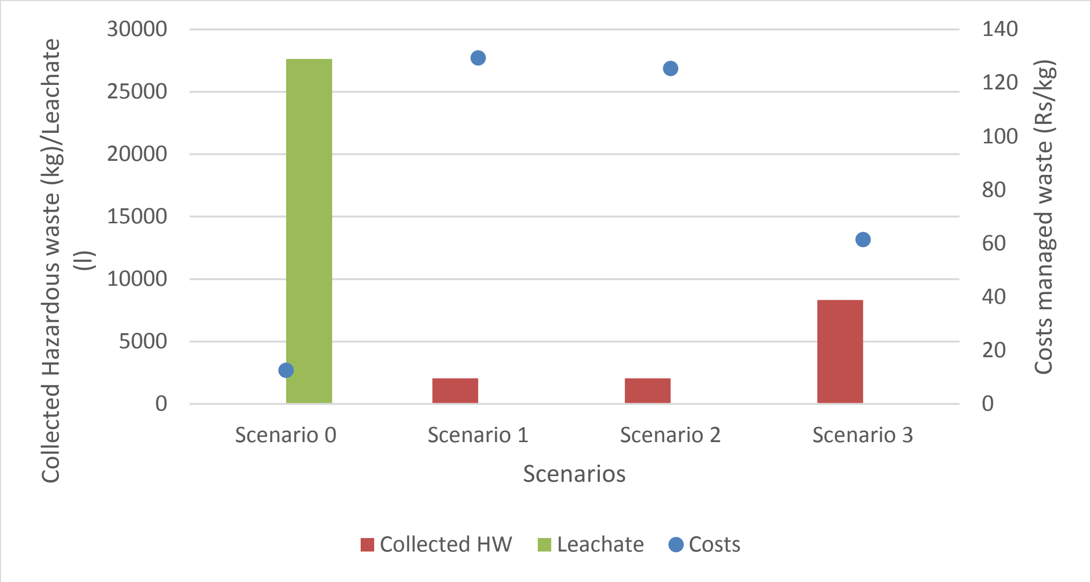


Figure 47: Combined financial and environmental assessment on scenarios; (WHO, 2008) (Own figure)

The combination of the financial and environmental assessments is the key figure to identify the most efficient HW management scenario.

“Scenario 0: Business as usual” is the cheapest scenario with the highest negative impact on the environment.

“Scenario 1: Collection and long-term storage with export of hazardous waste by trucks” is providing a hazardous waste management for the major settlement under the supervision of the SPCC. It takes out the complete possible contamination of heavy metals by collecting and storing hazardous waste and avoids leachate production.

“Scenario 2: Collection, storage and annual export of hazardous waste by plane” is constructed for storing the annual HW amount of approximately 2,100 kg and has comparable costs to “Scenario 2” due the export by plane. It provides the total avoidance of leachate.

“Scenario 3: Road connection to Lukla under the perspective of hazardous waste,” shows an increased hazardous waste emergence. With the implementation of a hazardous waste management, the total emerged hazardous waste is collected and leachate avoided. This scenario has the closest cost benefit solution.

By choosing residents for financing the HW management, a certain sensitization is implied which gives the ability of funding the HW management inside the community without any help through a foreign organisation. The direct collection of waste fees guarantees the continuance of the money within the SNPBZ.

The link between the present and the future is in the connection of “Scenario 1” and “Scenario 3”. “Scenario1” provides HW-management for the demands of protecting humans and the environment in SNPBZ and prepares on the increased requirements as forecasted in “Scenario 3”. First, experiences with the handling and possible changes may be implemented into the HW management. The HW-storage, designed in “Scenario 1” for catching the collected hazardous waste for five years, is in “Scenario 3” able to store the annual accumulated hazardous waste. So the construction costs in “Scenario 3” are dropped, which makes it makes it cost efficient for the future task of providing a hazardous waste management system with a complete avoidance of leachate from hazardous waste.

6. Discussion

6.1 Discussion of results

6.1.1 Results from literature data collection

The main point for waste management in developing countries is the collection (Brunner and Fellner, 2007), which is already integrated in a functioning and practised solid waste management in the SNPBZ. Focusing on hazardous waste, a specific waste fraction was chosen and investigated.

The applied 3R Concept with its reduce, reduction and recycling, offers Nepal the opportunity of exporting hazardous waste to other countries in order to attain revenue from batteries or lead batteries which are in use in the SNPBZ at the lodges. At the end of the lifecycle of the batteries, the lead could be an export good for trading and financing other waste management activities.(Visvanathan, 2010) The SPCC which runs the solid waste management, is imbedded as organisation in the strained financial structure of a developing country like Nepal. Without the help from abroad, in form of the NGO Eco Himal, the development of a sustainable solid waste management is not possible. As seen in the comparison between revenues and expenditures for the current solid waste management, the gap implies that the solid waste management can´t be sustainable in the long run. For transforming the current solid waste management in a sustainable solid waste management, stable income sources beside the icefall route fee have to be found.

The awareness of hazardous waste in a developing country like Nepal, is at the beginning of the stages of proper hazardous waste management. (Chanel, 2012) The first of five stages deals with the problem of identification and legislation, followed by the second stage with selection of a lead agency and the third stage of promulgation of rules. The last two stages are defined by creation of a mature compliance and enforcement program (Kahn, s.a.). With focusing on hazardous waste in a world heritage site in Nepal, this thesis may help to introduce possible pathways for achieving a new standard in dealing with hazardous waste in a developing country.

There is no specific definition regarding “Hazardous waste”. The only definition constitutes that “Hazardous Waste” means that goods, substances and radioactive rays discharged in different forms cause degradation of the the natural environment and harm human health and the life of other animals. Connected with the more general objectives of solid waste management, a precise definition on hazardous waste cannot be concluded. Also there are no links to thresholds or law material which would declare an exact image of what hazardous waste is and how it reacts in the Nepalese understanding. In order to provide an international definition on hazardous waste, the Basel Convention was used. Due the use of the definitions from the Basel Convention, ashes from burning processes, as it occurs in the SNPBZ, were not taken into account. It demonstrates in what direction a Nepalese “hazardous waste” definition could be aimed.

Beside the legal definition of hazardous waste, a treatment and/or disposal of hazardous waste in combination with general waste is also missing in a governmental document. The responsible authority for the waste management is the local legal body, which is out of the perspective of a national wide, Nepalese hazardous waste management, a barrier for building of treatment plants.

Information regarding socio-economic factors and waste management is fragmentary and inconsistent and not available by literature research. For a consistent and stable research design a field visit was conducted. Available records for the waste collection and financial situation are interpolated, e.g. if annual information on waste emergence was missing. Information from the “Solid waste management plan, 2014-2018” (Shahi and Shrestha, 2013) had been interpreted differently or extended. Records for hazardous waste in Nepal do not exist.

Figure 48: Comparison revenues and expenditures per ton and year for the current solid waste management in the SNPBZ; (Shahi and Shrestha 2013) (Own figure)

As described in the current status of the solid waste management, expenditures and revenues are trending apart. The sources for revenues for the current solid waste management are incomplete listed in the literature. Concerning expenditures the specific expenditures on street sweeping, collection, treatment and disposal and on SPCC staff are not figured out. The expenditures are rising annually, while the quantity of collected waste is decreasing. With a detailed breakdown, the widening gap between revenues and expenditures could also be explained. Explanations aren´t found in the literature or by local authorities. Transparency in the accounting records is not given. This trend with the widening gap is also observed over the last decade.

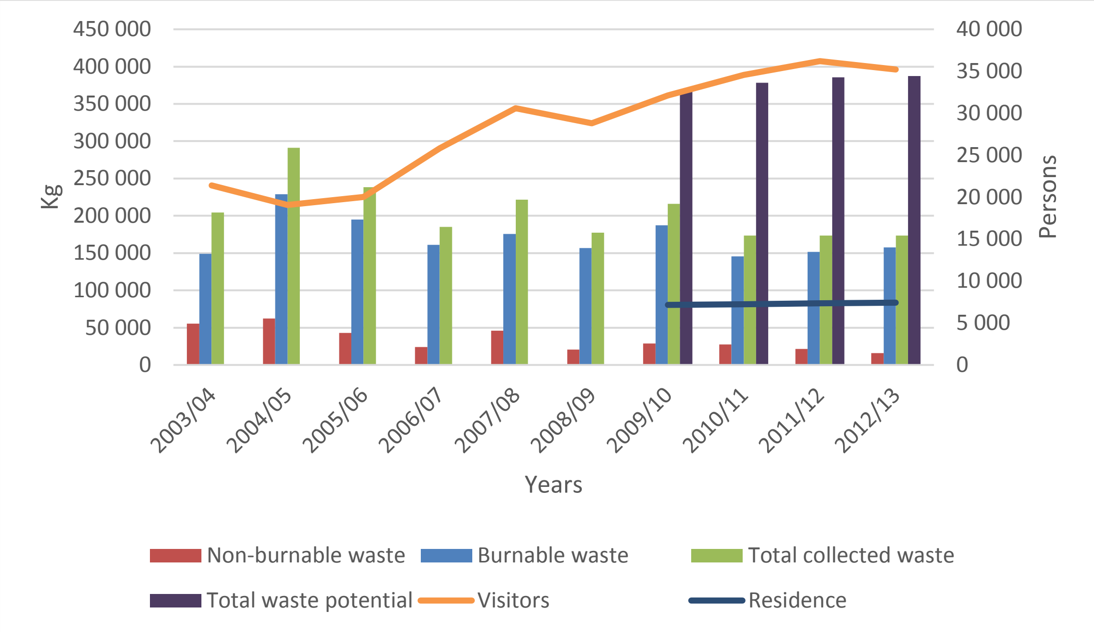


Figure 49: Waste collection in contrast to population numbers; (CBS, 2011) (Kali Bahadur, 2014; Zuser et al., 2011) (Shahi and Shrestha, 2013) (Own figure)

The analysis indicates that the relationship between collected waste from the SPCC and the visitor numbers could be the reason for the widening gap between collection and waste generation. As the SPCC covers the major settlements in the SNPBZ, it is implied that the SPCC collects also the tourism induced waste emergence. The served private households which are served by the SPCC are in the immediate catchment area of the SPCC served tourism establishments. This leads to the waste fee collection. Since 50% of the resident’s emerged waste is collected by the SPCC, the covered 50% are also addressed as hazardous waste fee payers. It is expected, that the 50% of the residence which are users of the solid waste management from the SPCC, are connected to the tourism industry and therefore accessible to revenues, which are not locatable for residence beside the tourism industry.

Beside the fact that the waste potential has its calculation basis in the literature, it is a first approach on the achievement level of waste management from the SPCC and may be used for further planning of waste management activities, collection schemes and disposal sites. Also based on these calculations, future public relations, like workshops and trainings or financing of services related with waste management are possible and projectable. In order to provide a measurement of results, the waste potential may be used. In perspective of hazardous waste, the waste potential may not be calculated under the consideration that a small fraction like hazardous waste is subjected by a high variance of appearance. (Lechner, 2004b)

6.1.2 **Results from field visit**

A sorting analysis was conducted to gain information on the hazardous waste fraction on dumps and daily advents. The investigated dumps had been between Lukla and Namche Bazar. The above mentioned dumps weren't implemented into the investigations. Lukla and Namche Bazar are the main villages for tourists connected through the only possible pathway within the National Park. A total survey on hazardous waste emergences in the SNPBZ on dumps is too expansive for one master thesis.

Dumps were served and analysed. Dumps which had been located near riverbanks or dry riverbanks during the dry season were washed away by the Koshi River during its swelling in the monsoon season. At the location from the irrigated dumps in the river banks, no new dumps had been discovered. This leads to the statement that informal dumps are not on a specific place but the river is intended for disposing waste in order of swapping the waste downstream during the monsoon. During the field visit, no new evolving dumps where detected. Possible reason was the starting visitor season for trekkers in the year 2014.

Difficulties in conducting the sorting analysis had been occurred in form of identifying dumps as concentrated location to one point, as two dumps had been a broad field of waste on the plane ground.

The investigated dumps are pits in the ground without any engineered barrier to the surrounding soil. Further investigations on the soil and rock as single barrier for non-burnable waste and ash are not conducted in this thesis.

Unknown at the field visit was the leaching capacity from the investigated hazardous waste on dumps and their influence on the groundwater. The realistic leachate and in-tray into the groundwater is estimated many times higher as described in this thesis. The leachate behaviour depends in various factors like water input, solvable contaminates, type of waste and age of dumps. (ISWA, 2008) A comparable study on leachate behaviour in a monsoon region was taken from the literature. (Karnchanawong and Limpiteeprakan, 2009) The same approach was conducted by BRUNNER and FELLNER (2007) for comparing the leachate production of dumps in developed and developing countries.

6.1.3 **Assessment of current hazardous waste management and scenarios**

All scenarios end with the export to Kathmandu. A further perspective on specific treatment and disposal possibilities is going beyond the scope of a master thesis. It is more feasible to export hazardous waste out of a natural and cultural heritage site which is poorly accessible than disposing hazardous waste in the Sagarmatha National Park and Buffer zone. Different small scale treatment possibilities in Nepal were introduced in this thesis. Nepal is at the very beginning of providing adequate treatment and disposal facilities. (Chanel, 2012) Kathmandu offers the possibility of an easy access for further potential treatments or disposal options.

Against the install of an own treatment facility for HW, stands the low amount of hazardous waste. Also a dismantling facility for recycling possible materials with value out of disposed electronic or electrical devices would suffer from a lack of input. The main challenge in installing a hazardous waste management system is the lack of knowledge and willingness. With providing the master thesis to the decision makers from the SPCC and their addressed public, a first approach in overcoming the inhibition threshold is conducted. Connected information leads to knowledge, which is the greatest leaver to a hazardous waste management. By installing one responsible person for solid waste and hazardous waste management, forces can be bundled and directed into specific actions. The uncontrolled dumping of hazardous waste, has to overcome in the first place the unwillingness to collect hazardous waste separately. The key to a proper waste management is beside installing storage places and collection schemes, in providing information to the concerned public by information campaigns, trainings and education in school is currently organised. Information campaigns like these are already encouraged and organised by the NGO Eco Himal. Children as adults are than capable to multiply gained knowledge about waste management into the common sense of general public.

Regarding the cost comparison for the scenarios, in which the “Scenario 0” is the cheapest scenario. Most costs in “Scenario 0” are externalised into the environment by the most dumping waste openly. (LaGrega et al., 1994) The real costs for collecting hazardous waste and avoiding leachate are internalised in “Scenarios 1,2,3” which makes them naturally more expensive.

The leachate as environmental indicator was picked as it reflects the characteristics of hazardous waste better than greenhouse gases.

6.2 Discussion of methodology

By repeating of the methodology from the SAME Report, in this master thesis, three aims have been tried to be achieved:

1. With repeating the methodology already conducted and approved methods are applied for the same research area as in previous reports
2. Results from the waste sampling are comparable to former waste samplings and allow a cross check over several years and publications
3. Stakeholder that are interested in the outcomes of this thesis, are able to compare the actual out comings with previous studies.

6.2.1 Waste sampling

The waste sampling was taken into reason of the lack data on hazardous waste. With the sorting analysis, first information on quantity and characteristics of hazardous waste is gained. Due to the low budget and high feasibility (Lechner, 2004b), the waste sampling was an approach for getting information about the waste composition of the dumps and at the incinerators. Previous studies on the waste composition have tried to find a resemblance with the own investigated results. Without the help from Miss Lakpa Sherpa, the investigations would not have taken place in its current form.

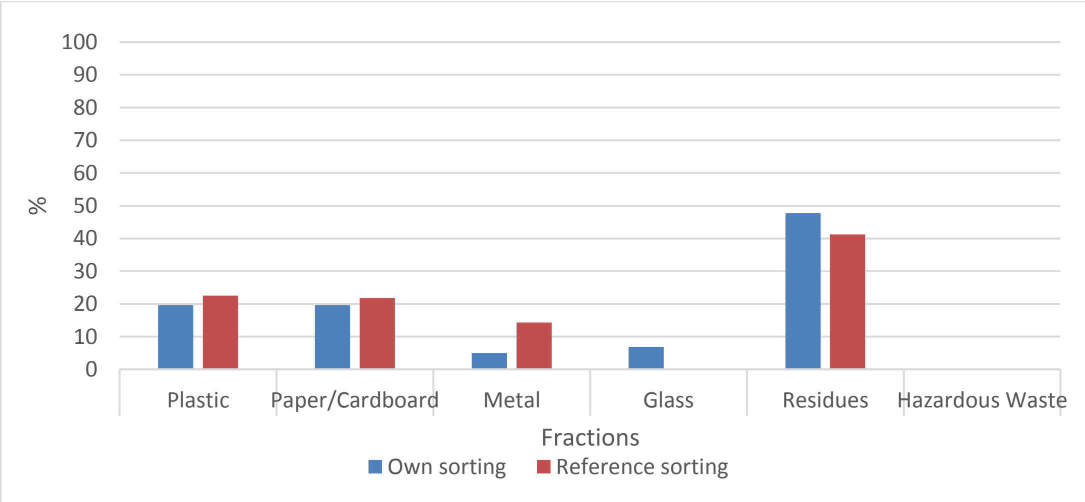


Figure 50: Comparison on waste composition; (Zuser et al., 2011) (Own figure)

The waste composition at the incinerators matches with previous studies. Deviations to other studies are in the residues fraction, which is higher than in the reference study (Zuser et al., 2011) and the “Metal, Glass fraction”, which was separated. The main advantage in comparing two studies on the waste composition was the fact that the reference study had a significant higher sampling size (33 kg) and range. The equality over the compared fractions are confirming the validity of the own researched waste data as basis for the later designed scenarios.

Information on hazardous waste was gained through sorting analysis at the incinerators and dumps in Lukla and Namche Bazar. The incinerators in the SNPBZ are serviced by the SPCC. The sorting analysis of collected general solid waste at the incinerators brought 1% of hazardous waste. It has to be considered that small fractions are underlying a high variance of appearance. (Lechner, 2004b) The conducted sorting analysis was executed in the early tourism season and with a comparable low sampling size and range. Approximately 0,1 of the annual collected waste was sorted, so the postulated 2,100 kg of hazardous waste has to be seen in a more qualitative way.

6.2.2 Material flow analysis

Major difficulty in applying the MFA quantitatively was the lack of records on how many goods are imported into the SNPBZ. An attempt to record the annual distribution for hazardous waste vulnerable goods was conducted. The main difficulty was the circumstances that many business owners who are dealing with HW vulnerable goods are cooperative in giving information on sales figures but only speak Nepali. Miss Lakpa Sherpa helped comprehensively on investigating basic information what is distributed by major business owners in the SNPBZ.

Extensive examinations would be needed on each stakeholder in order to provide a reliable source for building a complete MFA on it. A unit which could conduct this task of recording the imports into the SNPBZ is implied in “Scenario 2” as “Governmental Import-Export Control Unit”, with additional surveys on stakeholders within in the existing waste management, a complete MFA may be performed.

Reason for picking the material flow analysis was the broad appliance in demonstrating pathways of waste streams in systems like cities or areas like SNPBZ. (Scheinberg et al., 2010)

6.2.3 Assessment methodology

With applying an assessment for the designed scenarios the indicators were not given through the Nepalese legislation. Therefore the protection of the natural heritage site, in form of avoiding leachate from hazardous waste, was taken as first assessment indicator. With calculating leachate as indicator, a clear indicator is defined.

The second assessment indicator is the financial costs that represent the financial situation on which the scenario is built upon. The financial costs represent also the feasibility for a developing country like Nepal and are also a clear defined indicator.

Both indicators indirectly measure the impacts on environmental protection and feasibility. Indirect means here, that the heavy metals which are solved in the leachate are responsible for different diseases and are leading to health care costs. The indirect financial indicator represents the theoretical feasibility which leads to the residents as waste fee payers. A hazardous waste management system can only exist sustainable if, the residents are in charge of controlling, using and maintaining it. With addressing residents, this sustainability should be accomplished. The 50% of residence which would pay the waste fee are involved in the tourism sector which gives the opportunity of regaining the costs for the waste fee from visitors.

An uncertainty remains in the lack of information and if it is available, the quality of the information. If two scenarios are close together, a clear decision cannot be done. The same is valid for the calculated costs.

7. Conclusion

Due the lack of data on hazardous waste (HW), the starting point depicts the definition on hazardous waste according the Nepalese legislation. It has been concluded that the actual used definition lacks on specific criteria which determines hazardous waste clearly, the definition from the Basel Convention on hazardous waste was applied during the field visit and this master thesis.

The current situation for hazardous waste constitutes itself as followed; the local waste management is carried out by the Sagarmatha Pollution Control Committee (SPCC) which collects, treats and disposes of approximately 50% of the annual emerged general waste, within the SNPBZ, the other 50% of the general waste is unmanaged. The general waste composition departs itself into 48 % residues, 20% plastic, 20% paper/cardboard, 7% glass, 5% metal and 1% hazardous waste. The collected waste, is departed by the SPCC into the burnable and non-burnable waste fraction, hazardous waste is sorted into the non-burnable waste fraction and dumped openly in combination with non-burnable waste. Reason therefore are the typical items for HW; batteries, compact fluorescent light bulbs, gas cartridges, needles, infusion bags, medicaments, led containing paint. The HW fraction rises to 6% on dumps used by the SPCC and inhabitants. In total, annually 2,100 kg of hazardous waste is discarded in the SNPBZ.

The average expenditures for one kilogram of general solid waste is 13 Rs (0,13 $). Within this expenditure is the street sweeping, collection, treatment and disposal.

In order to provide a solution for the emerged HW in the SNPBZ different scenarios are designed for a HW management system beside the already existing general waste management system from the SPCC. The first aim of the designed scenarios are the protection of environment and humans, second aim was the inclusion of all stakeholders of HW in the scenarios, third aim was the preparation for future developments under the perspective of HW.

The “Scenario 0: Business as usual” analysis the status quo with the resulting impacts on the environment and humans. It describes the current collection, treatment and disposal of HW in combination with general waste.

“Scenario 1: Collection and long-term storage with export by trucks” investigates the implementation of a collection and central storage for HW. Including the future road connection to Lukla, the HW storage constitutes the stock for a five year catchment of hazardous waste and its export by trucks to Kathmandu.

“Scenario 2: Collection, storage and annual export by plane” assess the implementation of a collection and central storage for HW, designed for the catchment of one year. The export to Kathmandu is carried out via airplane.

“Scenario 3: Road connection to Lukla under the perspective of hazardous waste” describes the projected impacts on environment and humans if Lukla has a road connection. The changed demands to previous scenarios are included into the collection and storage schemes for hazardous waste.

Concluding with the current status in connection with the prognosis towards a future road connection to Lukla, the best solution for decision makers in the SNPBZ is to install the HW collection and storage scheme in “Scenario 1”. It meets the current demands with the capability of dealing with the projected developments in “Scenario 3”. The HW storage which is able to stock the hazardous waste of five years has the size for the expected hazardous waste catchment of year. Costs which are arising due the implementation of demanded HW management schemes are covered by waste fees.

Since the focus of this thesis is on the Sagarmatha National Park and Buffer Zone, the HW schemes are ending with the export to Kathmandu. The schemes are adapted to the specific demands of a world heritage site in a low income country like Nepal. In the end, it lies in the hands of the authorities and the concerned public in Nepal to install a countrywide HW system which includes the proper collection, treatment and disposal. With applying the presented scenarios, the SNPBZ would establish itself as role model for the uprising waste management in Nepal.

8. Literature

ADB, A. D. B. (2013): Solid Waste Management in Nepal: Current status and policy recommendations. Mandaluyong City, Philippines, Asian Development Bank.

Bank, A. D. (2013): Solid Waste Management in Nepal: Current status and policy recommendations. Mandaluyong City, Philippines, Asian Development Bank.

Data, Nepal, http://data.worldbank.org/country/nepal (28.11.2014)

Board, I. P. (1992): The Industrial Enterprise Act 1992. Kathmandu, Nepal, Government of Nepal.

Board, N. T. (1997): Nepal Tourism Board Act 2053 (1997). Kathmandu, Nepal, Government of Nepal.

Brunner, P.; Rechberger, H. (2004): Practical handbook of material flow analysis. The International Journal of Life Cycle Assessment 9: 337-338.

Brunner, P. H.; Fellner, J. (2007): Setting priorities for waste management strategies in developing countries. Waste Management & Research 25: 234-240.

CBS, C. B. o. S. (2011): National Population and Housing Census 2011. IN Secretariat, N. P. C. (Ed.) 1. Kathmandu, Nepal, Government of Nepal.

World Heritage List, http://whc.unesco.org/en/list/120 (16.6.2014)

Chanel, D. (2012): A regional pool of experts speak about hazardous waste issues in the Asia-Pacific region. TRP +Training Resource Pack. Youtube.

Commission, E. (2000): replacingDecision 94/3/EC establishing a list of wastes pursuant to Article 1(a) of Council Directive 75/442/EEC on waste and Council Decision 94/904/EC establishinga list of hazardous waste pursuant to Article 1(4) of Council Directive 91/689/EEC on hazardous waste. Brussel.

Commission, E. (2002): Commission Decision of 3 May 2000 replacing Decision 94/3/EC establishing a list of wastes pursuant to Article 1(a) of Council Directive 75/442/EEC on waste and Council Decision 94/904/EC establishing a list of hazardous waste pursuant to Article 1(4) of Council Directive 91/689/EEC on hazardous waste (notified under document number C(2000) 1147) (Text with EEA relevance) (2000/532/EC) Brussel.

Daconto, G.; Sherpa, L. N. (2010): Applying Scenario Planning to Park and Tourism Management in Sagarmatha National Park, Khumbu, Nepal. Mountain Research and Development 30: 103-112.

.

Dhungana, S. (2013): Steel, cement, aggregates prices send construction costs soaring My Republicá. Kathmandu, Nepal, Nepal Republic Media Pvt. Ltd.

EcoHimal Austria Gesellschaft für Zusammenarbeit Alpen-Himalaya, http://www.ecohimal.org/ (12.07.2014)

EPA, U. S. E. P. A. (1976): Resource Conservation and Recovery Act (RCRA). IN EPA, U. S. E. P. A. (Ed.). Washington DC, Unites States of America.

EPA, U. S. E. P. A. (1998): On-Site Incineration: Overview of Superfund Operating Experience. Solid Waste and Emergency Response (5102G).

EPA, U. S. E. P. A. (2002): Solid Waste Disposal Act. Washington DC, Unites States of America, EPA, United States Environmental Protection Agency.

EPA, U. S. E. P. A. (2009): Waste definitions. EPA 842/09 ed. Washigton DC, United States of America, U.S. Environmental Protection Agency.

EPA, U. S. E. P. A. (2012): Part 273 - Standards for universal waste management. Washington DC, Enviromental Protection Agency.

Basic Information about Chromium in Drinking Water, http://water.epa.gov/drink/contaminants/basicinformation/chromium.cfm#three (07.10.2014)

Air Toxics Web Site, http://www.epa.gov/ttn/atw/hlthef/mercury.html (07.10.2014)

Everest Summiteers Association, http://www.everestsummiteersassociation.org/ (12.07.2014)

AQUASTAT - FAO's Information System on Water and Agriculture, http://www.fao.org/nr/water/aquastat/countries_regions/npl/index.stm (27.10.2014)

Felix, F.; Fraaij, A. L. A.; Hendriks, C. F. (2001): Comparison of Stabilisation/Solidification-treatment of hazardous waste materials. Heron 46: 119 - 133.

Foundation, G. E. C. (2014): Rotary Kiln Incinerator. Osaka, Japan.

Garrat, K. (1981): Sagarmatha National Park Management Plan. Wellington, New Zealand, Department of Lands and Survey.

GOV, G. o. N. (1979): Himalayan National Park Rules, 2036 (1979). Kathmandu, Nepal, Government of Nepal.

GOV, G. o. N. (1997): Environment Protection Rules, 1997. Government of Nepal.

GOV, G. o. N. (2002): Mountaineering Expedition Rules, 2059 (2002). Kathmandu, Nepal, Government of Nepal.

Harather, K. (2013): Interim Storage of Hazardous Waste - A Complex Challenge. Seebenstein, Austria, IUT Ingenieurgemeinschaft Innovative Umwelttechnik GmbH.

Hawley, R. S. a. E. (2014): The Himalayan Database. 2014 ed. Colorado, United States of America, The American Alpine Club.

About Lukla Hospital, http://www.luklahospital.com/ (24.07.2014)

Findings on the Worst Forms of Child Labor - Nepal, http://www.dol.gov/ilab/reports/child-labor/nepal.htm (08.10.2014)

Iordanopoulos-Kisser, M. (2013): Erstellung eines Probenahmeplans. Durchführung der Probenahme und Probenaufbereitung. Chemie und Untersuchung von Abfällen. University of Natural Resources and Life Sciences, Vienna.

ISWA, W.-L. (2008): Lesson 4, Leachate management and control. ISWA.

Joshi, D. P. (1982): The climate of Namche Bazar: a bioclimatic analysis. Mountain research and development 2: 399-403.

Kahn, D. J. (s.a.): Hazardous Wastes Issues in Developing Countries. IN Kaseva, M. E. & Mbuligwe, S. E. (Eds.).

Kali Bahadur, R. (2014): Monthly tourist record since visit Nepal ´98. IN monthlytouristrecord2014.JPG (Ed.). Jorsalle, Sagarmatha national park information office.

Karnchanawong, S.; Limpiteeprakan, P. (2009): Evaluation of heavy metal leaching from spent household batteries disposed in municipal solid waste. Waste Management 29: 550-558.

Khanal, S. N. (2012.): Field trip to sanitary landfill site at Sisdol.

Kutz, M. (2009): Environmentally conscious materials handling. Hoboken, United States of America: John Wiley & Sons.

Safety and Health Topics, https://www.osha.gov/SLTC/hexavalentchromium/healtheffects.html (06.10.2014)

LaGrega, M. D.; Buckingham, P. L.; Evans, J. C. (1994): Hazardous waste management. Hazardous waste managemen.

Lechner, P. (2004a): Kommunale Abfallentsorgung. Kommunale Abfallentsorgung.

Lechner, P. (2004b): Kommunale Abfallentsorgung. Kommunale Abfallentsorgun.

Luger, K. (2011): Saving Mount Everest - Managing the solid waste of Sagarmatha national park and its Buffer Zone. IN Luger, K. (Ed.). Vienna, Austria, Eco Himal, Vienna University of Technology.

Luger, K. (2014): Saving Mount Everest. IN Luger, K. (Ed.). Salzburg, Austria.

Manfredi, E. C. et al. (2010): Solid Waste and Water Quality Management Models for Sagarmatha National Park and Buffer Zone, Nepal. Mountain Research and Development 30: 127-142.

Marques, T. (2012): Hazardous Waste Facilities in Developing Countries: Enhancing Local Emergency Preparedness through UNEP´s APELL Programm. Paris, France, UNEP, United Nations Environment Programme.

MEF, M. o. E. a. F. (2004): Dhaka Declaration on waste management 2004. IN Forest, M. o. E. a. (Ed.). Dhaka, Bangladesh, Government of the People's Republic of Bangladesh.

MFALD, M. o. F. A. a. L. D. (2011): Solukhumbu District, Adminstrative Boundaries. Kathmandu, Nepal, Government of Nepal.

MHPP, M. o. H. a. P. P. (1998): Town Devlopment Act, 1998. 22. Kathmandu, Nepal, Government of Nepal.

Mishra, S. B.; Kayastha, R. P. (1998): Solid waste management. A Copendium on Environmental Statistics. Kathmandu, Nepal, Central Bureau of Statistics.

MLD, M. o. L. D. (1996): Solid waste management, National Policy 2053 (1996). IN development, M. o. I. (Ed.). Kathmandu, Nepal, Government of Nepal.

MoH, M. o. H. (2003): Improving Health Care Waste Management in Nepal. Kathmandu, Nepal.

MOLJPA, M. o. L., Justice, Constituent Assembly and Parliamentary Affairs (1999): Local Self Governance Rules, 2056 (1999). Kathmandu, Nepal, Government of Nepal.

MPE, M. o. P. a. E. (1997): Environment Protection Act, 2053 (1997 A.D.). Kathmandu, Nepal, Government of Nepal.

MSFC, M. o. F. a. S. C. (1973): National Parks and Wildlife Conservation Act, (2029). Kathmandu, Nepal, Government of Nepal.

MTCA, M. o. C., Tourism and Civil Aviation (1981): Mountaineering Regulations 1979. Kathmandu, Nepal, Nepal Mountaineering Association.

MTCA, M. o. T. a. C. A. (2005): Travel and Trekking Agency Rules, 2062 (2005). Kathmandu, Nepal, Government of Nepal.

MUD, M. o. U. D. (1987): Solid Waste (Management and Resource Mobilization) Act, 1987. Kathmandu, Government of Nepal.

MUD, M. o. U. D. (2011): Solid Waste Management Act, 2011. IN development, M. o. u. (Ed.). Kathmandu, Nepal, Government of Nepal.

N. Ghimire, P. J. a. G. C. (2013): Physico-Chemical Parameters of High-Altitude Rivers in the Sagarmatha (Everest) National Park, Nepal. Journal of Water Resource and Protection 5: 761-767.

Pawson, I. G. et al. (1984): Growth of Tourism in Nepal's Everest Region: Impact on the Physical Environment and Structure of Human Settlements.

Pokhrel, D.; Viraraghavan, T. (2005): Municipal solid waste management in Nepal: practices and challenges. Waste Manag 25: 555-62.

Practical Action, N. (2008): Best practices on Solid waste management of Nepalese Cities. Kathmandu, Nepal, Practical Action, Nepal.

Rai, K. B. (2014): Monthly tourist record since visit Nepal ´98. IN monthlytouristrecord2014.JPG (Ed.). Jorsalle, Sagarmatha national park information office.

What a Waste: Solid Waste Managementin Asia, http://www.worldbank.org/urban/solid_wm/erm/CWG%20folder/uwp1.pdf (28.3.2014)

Reed, M. S. et al. (2009): Who's in and why? A typology of stakeholder analysis methods for natural resource management. Journal of Environmental Management 90: 1933-1949.

S.N. (2014): Sagarmatha national park. www.thebluespace.com.

Sangam, P. (2014): Everest region to be linked by motor road. The Kathmandu Post. Kathmandu, Nepal, Kantipur Publications Pvt. Ltd.

Scheinberg, A.; Wilson, D. C.; Rodic, L. (2010): Solid Waste Management in the World's Cities: Water and Sanitation in the World's Cities 2010. Earthscan on behalf of UN-HABITAT. London, United Kingdom, United Nations.

Services, R. I. D. (07.26.2010): Local Battery Manufacturing. Nepalganj, Nepal.

Shahi, A.; Shrestha, S. (2013): Solid waste management plan (2014-2018) of Sagarmatha Pollution Control Committee (SPCC). Namche Bazar, Nepal, Environment and Public Health Organization.

Sherpa, P. (2014): Organization of waste management in the Sagaramatha national park. IN Lichtberger, P. (Ed.). Kathmandu, Nepal, Eco Himal.

Shrestha, A. B.; Kumar, R.; Shen, Y. (2005): An Overview of Glaiers, Glacier Retreat, and Subsequent Impacts in Nepal,India and China. IN Gurung, T. (Ed.). Kathmandu, Nepal, World Wildlife Found.

Shrestha, A. S. a. S. (2013): Solid waste management plan (2014-2018) of Sagarmatha Pollution Control Committee (SPCC). Namche Bazar, Nepal, Environment and Public Health Organization.

SPCC, S. P. C. C. (2012): Annual Report 2011. Annual Progress Report. Namche Bazaar, Nepal, Sagarmatha Pollution Control Committee.

SPCC - Sagarmatha Pollution Control Committee, http://www.spcc.org.np/index.php (05.07.2014)

Standardization, E. C. f. (2006): EN 15002 Characterization of waste - Preparation of test portions from the laboratory sample. Brussels, Belgium.

Statistics, C. B. o. (2008): Report on the Nepal labourf force survey 2008. IN Statistics, C. B. o. (Ed.) First ed. Kathmandu, Nepal, Government of Nepal.

Statistics, C. B. o. (2011): National Population and Housing Census 2011. Kathmandu, Nepal, Government of Nepal.

Statistics, C. B. o. (2012): National Population and Housing Census 2011. IN Secretariat, N. P. C. (Ed.). Kathmandu, Nepal, Government of Nepal.

Trekking Agencies' Association of Nepal (TAAN), http://www.taan.org.np/introduction/about-us (12.07.2014)

Sir Edmund Hillary Projects, http://www.siredmundhillary.com/projects.htm (24.07.2014)

UNEP, U. N. E. P.-. (1989): Basel Convention - On the control of transboundary movements of hazardous wastes and their disposal - Texts and Annexes. IN Convention, S. o. t. B. (Ed.). Geneva, Switzerland, Secretariat of the Basel Convention.

Sagarmatha National Park, Nepal, http://www.eoearth.org/view/article/155820 (03.07.2014)

UNEP, U. N. E. P.-D. o. T., Industry and Economics (2012): Chapter 2.1 - Definition and classification. IN Singapore, N. E. A. o. (Ed.) Workshop on Training Resource Pack on hazardous waste in Singapore. Singapore, UNEP - United Nations Environment Programme.

UNEP, U. N. E. P.-S. D. (2011): Hazardous waste generation. New York, United States of America, United Nations.

Sagarmatha national park, Nepal, http://www.conservation-development.net/Projekte/Nachhaltigkeit/DVD_12_WHS/Material/files/WCMC_Sagarmatha.pdf (17.06.2014)

UNESCO, W. H. C. (2007): UNESCO World Heritage Centre publications on climate change. 32. Online: http://whc.unesco.org/uploads/activities/documents/activity-397-2.pdf (30.06.2014).

World Heritage List, http://whc.unesco.org/en/list/120 (16.6.2014)

Metals in Medicine and the Environment, http://faculty.virginia.edu/metals/cases/rasnake1.html (06.10.2014)

Metals in Medicine and the Environment, http://faculty.virginia.edu/metals/cases/rasnake1.html (06.10.2014)

Visvanathan, C. (2010): 3R Challenges and Opportunities in Industrial Hazardous Waste. Environemtal Engineering and Management Program,

Asian Institute of Technology,

Thailand.

Vögeli, Y.; Sylvie, P. (2008): Sandec Training Tool 1.0 - Module 6. Solid Waste Management. Dübendorf, Switzerland, Eawag/Sandec, Department of Water and Sanitation in Developing Countries.

WHO, W. H. O. (2008): Guidelines for drinking-water quality: incorporating 1st and 2nd addenda, Vol.1, Recommendations. – 3rd ed. Geneva, Italy, World Health Organization.

Zuser, A.; Fellner, J.; Lederer, J. (2011): Saving Mount Everest - Managing the solid waste of Sagarmatha national park and its buffer zone. Vienna, Salzburg, Austria, Department of Water Quality, Resource- and Waste Management.

9. ANNEX

Curriculum Vitae

Paul **Lichtberger**

PERSÖNLICHE INFORMATIONEN

Straße	Schanzstrasse 3/17-18
Ort	1140 Wien
Telefon	0043 (0)650 53 67 089
E-Mail	paullichtberger@gmx.net
Staatsbürgerschaft	Österreich
Geburtsort	Deutschlandsberg
Geburtsdatum	14 Juni 1986

BILDUNG

Mär. 2012 – Juli. 2015

Universität für Bodenkultur
Masterstudium: Umwelt- und Bioressourcen Management
Schwerpunkt: Abfallwirtschaft

Masterarbeit: *Hazardous waste management in natural heritage: A case study from the Sagarmatha National Park and Buffer Zone in Nepal*
Prof. Dr. Helga Kromp-Kolb; Zentrum für Globalen Wandel & Nachhaltigkeit, BOKU Wien;
Prof. Dr. Kurt Luger; Abteilung Transkulturelle Kommunikation, Universität Salzburg

Okt. 2006 – Feb 2012

Universität für Bodenkultur
Bachelorstudium Umwelt- und Bioressourcen Management

Bachelorarbeit am Institut für Waldbau zum Thema: *Der Wald als Kohlenstoffsenke: Chance und Risiken für den Klimawandel,* Prof. Dr. Rupert Seidl

Mai 2006 **Bundesoberstufenrealgymnasium** Deutschlandsberg
Matura, naturwissenschaftlicher Zweig.

PUBLIKATION

Mär. 2015 **5. Wissenschaftskongress "Abfall- und Ressourcenwirtschaft" der deutschen Gesellschaft für Abfallwirtschaft e.V.,** Innsbruck
Hazardous waste management in natural heritage: A case study from the Sagarmatha National Park and Buffer Zone in Nepal

BERUFSERFAHRUNGEN

Mär. 2015 – laufend **Magistratsabteilung 48: Abfallwirtschaft, Straßenreinigung und Fuhrpark, Wien**
Assistenz und Controlling

Mär. – Mär.2013/15 **Eventmanagement Universität Wien**, Wien
Mitarbeiter

Jul.- Aug. 2007/14 **Firma Weichberger**, Deutschlandsberg
Zweiradmechaniker

Dez. – Jan. 2011/12 **Spinning Circle**, Fahrradkurierdienst, Wien
Bote

Aug.- Sep. 2010/13 **Spedition Klusk**, Wr. Neudorf
Kommissionierer

Jul. – Aug. 2008/09 **Magistratsabteilung 48**, Wien
Aufleger

Jän.-Dez. 2008 **Moments & Movements**, Österreich, Schweiz,
Photograph

Jän.-Mär. 2008	**Schischule Klinger**, Deutschlandsberg, Snowboardguide
Jul. 2005/06	**TDK**, Deutschlandsberg, Ferialpraktikant

PRAKTIKA

Mai-Sep. 2012	**Universität für Bodenkultur**, Institut für Abfallwirtschaft, Wien
Apr. 2012	**Bundeministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft, Abteilung Abfallwirtschaftsplanung, Abfallbehandlung und Altlastensanierung**, Wien
Jul.-Aug. 2012	**Arbeitsgruppe erneuerbare Energie Vorarlberg**, Alberschwende
Apr.- Mai. 2011	**Land Steiermark, Fachabteilung Abfall- und Stoffflusswirtschaft**, Graz
Feb. 2010	**Land Steiermark, Fachabteilung Energiewirtschaft und allgemeine technische Angelegenheiten**, Graz
Sep.-Dez. 2009	**Koordinierungsstelle der Österreichischen Bischofskonferenz für internationale Entwicklung und Mission,** Wien

ZUSATZQUALIFIKATIONEN

Kurse	Motorsägenarbeits- und Sicherheitskurs für Studenten (Feb. 2009)

Jungendleiter beim Österreichischen Alpenverein
(seit 2006)

Seminare

Verhandlungstechnik
(Dez. 2014)

Die Führungspersönlichkeit in mir
(Okt. 2014)

Rhetorik und Präsentationstechnik
(Okt.-Nov. 2009)

Coaching für Führungskräfte
(Mär. 2013)

Erstsemestrigentutorium
(Sep. 2008)

Ausbildungen

Abfallbeauftragter
(Jän. 2015)

Tagungen

ISWA Beacon Conference
„Waste Minimisation and Recycling"
May 2015

Österreichische Abfallwirtschaftstagung 2011,
„Wieviel Abfall braucht der Mensch?"
(Apr. 2011)

Friedensakademie 2007
„Energie/Ressourcenknappheit und Krieg"
(Jul. 2007)

SPRACHEN UND EDV-KENNTNISSE

Deutsch	Muttersprache
Englisch	Verhandlungsfähig
Italienisch	Basiskenntnisse
PC	ECDL
Führerschein	Klasse B

INTERESSEN

Kochen
Reisen
Photographie
Mountainbiken

Paul Lichtberger