IMPROVING MICROBIOLOGICAL DRINKING WATER QUALITY IN THE CITY OF TASHKENT:

A Reconnaissance Study

Guzal Abduraupova – 920622003080

MSc Thesis in Environmental Science

ESA – 80436

February 2017

Supervisor:

Dr.ir. N (Nynke) Hofstra, Environmental Systems Analysis Group, WUR

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Preface and Acknowledgements

This thesis is one of the fruits of my academic life. It was written based on my personal ambitious desire to make the population of Tashkent to be able to safely drink water from the tap. When I was in BSc in Water Resources Management, I was not able to conduct the research close to the topic of my interest. But, here, at Wageningen University I got the opportunity to do it. It was a huge challenge to accomplish the set of goals due to lack of data, short time period, however, I am satisfied with my achievements. I felt great joy to find out that there was a possibility to enhance the quality of drinking water in the City of Tashkent. I have no doubt that this thesis, its structure can be a good guidance for the prospective students who want to continue this study. Moreover, I succeeded to create a basis for my further research.

Several persons have contributed academically, practically and with moral support to write this MSc thesis. Therefore, first of all, I want to thank my head supervisor Nynke Hofstra and Environmental Sciences programme director Theo Lexmond who helped me to conduct my research at Wageningen University. Furthermore, I would like to express my sincere gratitude to my wonderful parents, Gavhar Abduraupova and Ramz Abduraupov, brother Rustam Abduraupov and my dear aunty Okila Salieva for contributing their expertise in all kind of spheres. Thanks to them I was able to get a degree of one of the best universities in the world. Also I am grateful to my best friend Malika Olimova for her constant help. Last but not least I want to thank my husband Abdulla Sadayev for a huge support, love and being in my life.

I hope you will enjoy reading this thesis.

Guzal Abduraupova

23/02/2017

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Summary

Drinking water is abundantly available in the Uzbek capital Tashkent. However, its quality remains questionable. People refuse to directly drink tap water and prefer to boil the water before drinking or buy bottles water, which is considered safer and purer. This fear is not without reason. Tap water can be contaminated with pathogens that cause water-related illnesses. Providing safe drinking water is the main task of the State Unitary Enterprise (SUE) "Suvsoz" supplies most of Tashkent's tap water. Their distributed water stems from surface water, which is treated with Chlorine. Infectious pathogens, such as *Cryptosporidium hominis* and *Cryptosporidium parvum,* that can cause severe watery diarrhoea, in humans, are likely present in this surface water because the sewer treatment plants only provide limited treatment for *Cryptosporidium*. Moreover, these pathogens are resistant to Chlorine. This means that tap water is likely contaminated. The actual presence of *Cryptosporidium* in tap, however, is unknown, because its detection is considered prohibitively expensive. Nevertheless, "Suvsoz" does likely not fulfill its own mission to provide safe drinking water to the inhabitants of Tashkent.

This thesis investigates how the population of Tashkent is able to safely drink 2 litres of tap water. I aim to (i) to propose solutions to improve Tashkent's microbiological drinking water quality; and (ii) assess costs and benefits of the most suitable water treatment method. To achieve my aims my research was divided into two parts. First, the tool "Quantitative Microbial Risk Assessment" (QMRA) is used and second costs and benefits are analyzed microbiological concentrations in the city of Tashkent were retrieved from simulation with the Global Water Pathogen (GloWPa) model. Estimates were 3.9 log10 oocysts per litre, which is more than 100 oocysts per litre. This means that Tashkent's water is grossly polluted. When this is combined with the two daily litres of water per person and dose-response relation to assessing risks (obtained from the literature), the annual risk of infection is 100% ($person^{-1}yr^{-1}$). This number, however, excludes immunity. This means that everyone gets infected at least once per year.

Water-treatment methods other than adding Chlorine could be effective. For example, Ozonation has a 1.5 log10 and UV treatment has a 3.0 log10 reduction. However, even after Ozonation or UV applications, the annual infection risk remains 100%. This means that the possibility of getting infected by Cryptosporidium is still very high since the acceptable annual risk is 0.01 % (i.e. 10,000 times less). However, as Tashkent's oocyst concentration is poorly known, the same study was done with a concentration of 100 oocysts per litre (i.e. grossly polluted). The risk is also not reduced in this case, and even applying UV is insufficient to produce safe drinking water. Thus, Tashkent's population should continue to boil tap water or alternatively, another treatment or a combination of treatment should be applied to achieve acceptable annual risks.

The research second part mainly focused on assessing the costs and benefits of different approaches. Since GloWPa's results are an uncertain literature review and dose-response analysis helped to show that UV has the highest reduction rate compared to chlorination and Ozonation, assumed that UV is the most effective. Firstly, disability-adjusted life years (DALY) for the whole population in Tashkent were calculated. This results in 3300 DALYs and each DALY costs net €59000. This thus means that when Tashkent's drinking water is effectively treated, this would likely safe annually €330 million.

Next, the costs for the needed medical services were estimated and compared to the benefits of applying a UV treatment device at the household level.

These costs are person specific. I developed for scenarios in which the number of sick days and the medical testing and treatment were varied. The costs are €341 per person for the scenario that includes a week hospitalization of individual together with diagnostic testing, dietary needs, and medical supplies. The most realistic scenario involves a person having watery diarrhoea caused by Cryptosporidium, but he/she does not want to be hospitalized and prefers to receive treatment on his/her own without skipping the work. However, in fact, hospital bed days and diagnostic testing for infectious diseases in Uzbekistan are currently free for all citizens. This person would still consume dietary food and takes full medical supplies. In this scenario, a person spends €84. The costs of UV, tap water treatment include the average costs of the initial installment of €1500 per household, a UV dose of approximately €16.50 per year, the costs for annual filter maintenance. Assuming the costs of medical treatment totals €84 for the latter scenario and UV treatment installation eliminates the risk of becoming ill, for years are required for the return on initial investments. The current costs are probably less as the population currently does not have a risk of 100% to become ill because they boil water or buy bottled water. These costs could only occur in case people would daily drink two litres of contaminated water.

Further study to apply this approach to better reduce the risks include more precise measurements of Cryptosporidium concentrations in the City of Tashkent and better determining the efficiency of drinking water treatment approaches. However, despite the hypothetical nature of this thesis, my approaches to assess risk and costs is sound.

Introduction

1.1. Problem Statement

1.1.1. Safe drinking water

Access to safe drinking water is a huge issue for a large part of the world. According to WHO/UNICEF (2015), one out of ten people lacks access to safe drinking water. Indeed, the drinking water crisis is one of the biggest threat to the wellness of the society (World Economic Forum, 2015) The growth of the population on our planet enlarged water consumption. As a result, the water deficit considerably increased. In turn, this led to worsening living conditions and slowed down economic development of the countries that already had a deficiency. Providing pure drinking water for the citizens has been an issue for Uzbekistan for many years. Citizens are afraid to drink water from the tap directly and prefer to buy bottled water as they consider it safer and purer, or they boil tap water first. They fear being infected by water-related illnesses. Stanwell-Smith et al. (2003) claim that these diseases are considered as a major root of morbidity and mortality. Meanwhile, potable water must be safe and be free of pathogenic microorganisms that cause such illnesses as diarrhoea, gastroenteritis, dysentery, and cholera.

1.1.2. Drinking water facilities in Tashkent

The city of Tashkent is the capital and the largest city of Uzbekistan with a population of 2.3 million people. The potable water supply system of the city of Tashkent is the oldest and the most developed system in Uzbekistan (World National Consultation, 2015). The water supply of Tashkent is accomplished via two sources: surface- and groundwater located in the basin of the Chirchik River (World National Consultation, 2015). 76 per cent of the water is supplied from surface water intakes and 26 per cent from groundwater (Salidhodjaev, 2000). The operation of complex water and sewage systems is provided by water and sewage trust of Tashkent, namely, State Unitary Enterprise (SUE) “Suvsoz”. It is a state-owned enterprise, which is an independent legal entity operating fully on a self-sustained basis. The main task of the SUE “Suvsoz” is a to ensure a continuous supply of safe drinking water which fits quality requirements to the population of the city of Tashkent and Tashkent region (Kibray district and Zangiata district). SUE “Suvsoz” centralized water supply covers almost all citizens (only 70,000 are not covered) and provides an area of 340 square kilometres with treated water (Suvsoz, 2016).

To purify drinking water containing pathogenic microorganisms, a specific treatment called disinfection is required. In Uzbekistan, centralized water treatment plants exist mostly in big cities, including Tashkent. The urban water treatment plant in Tashkent, based on its power, is the largest water treatment facility in the whole Central Asian region (Salidhodjaev, 2000). Before water enters the distribution network, a water quality control is executed in accordance with the recommendations by type, content, and frequency of conduction of the analysis based on the State Standard of Uzbekistan "Drinking Water Hygienic Requirements and Quality Control"[1]. Note, however, that the laboratory SUE "Suvsoz" conducts laboratory tests of the drinking water quality on an hourly basis, regardless of holidays and weekends (Suvsoz, 2016). Moreover, according to WHO/UNICEF (2015), the proportion of the urban population served with the improved water treatment system equals to 100 per cent. To purify water from different micro-organisms and provide safe drinking water, SUE "Suvsoz" uses liquid Chlorine and sodium hypochlorite.

1.1.3. Cryptosporidium

One of pathogenic micro-organisms is *Cryptosporidium*. This pathogenic protozoan parasite is a kind of simple, single-celled, member of the genus *Cryptosporidium* that causes diseases of the digestive tract of the people around the world (Hofstra, Bouwman, Beusen, & Medema, 2013). *Cryptosporidium* remains a major hazard to people health for two main reasons (Leav, Mackay, & Ward, 2003): firstly, the available methods of drinking water treatment are not effective enough; secondly, the therapy for cryptosporidiosis is ineffective. Cryptosporidiosis is caused by being infected by the oocyst of *Cryptosporidium*, the disease of the person which is transmitted in the fecal and oral way and shown most often in the form of watery diarrhoea. At normal immunity conditions of people, oocyst of *Cryptosporidium* causes short diarrhoea that passes without the necessity for any medical treatment. But, those who are in a vulnerable group (children up to five years old, people with AIDS etc.) are faced with being infected by *Cryptosporidium*. To prevent people from being infected, drinking water should be properly treated in order not to exceed an acceptable level of risk of infection by oocyst of *Cryptosporidium*.

Drinking water treatment by Chlorine assuages all types of microbial waterborne pathogens like protozoa, viruses, and bacteria. However, pathogen called *Cryptosporidium* is naturally resistant to Chlorine. Meanwhile, the Research Institute of Sanitation Hygiene and Occupational Diseases of the Ministry of Health of Uzbekistan (2006) claims that the currently used method for the sanitary - parasitological study of drinking water is aimed to identify oocysts of pathogenic intestinal protozoa in the water (giardia, dysentery ameba, balantidium) and helminth eggs. However, the method is not intended to identify *Cryptosporidium* because determination requires more complex preparation of diagnostic materials and the use of expensive special test systems, which are not currently manufactured by national producers. Also, Suvsoz (2016) mentions on their official website that "in recent years new methods of water disinfection were developed. But they are still more expensive than chlorination and does not guarantee infection of already treated water after it has gone through the pipes. So give up on the Chlorine is too early".

Hence, SUE "Suvsoz" drinking water is fully available in the city of Tashkent provided by SUE "Suvsoz". However, its drinkability remains questionable and consumption of two litres of

[1] State standards of the Republic of Uzbekistan (2011) Standard number O'zDSt 950: 2011, Drinking Water Hygienic Requirements and Quality Control", Last modified on 2011, Not available in English

tap drinking water directly from the tap would be an ideal situation for citizens of the city of Tashkent. But, if water is contaminated, its ingestion without its boiling causes health risk of being infected by Cryptosporidium. But in fact, data on the concentration of Cryptosporidium in potable water (that mostly comes from surface water) and on treatment against Cryptosporidium in Uzbekistan is not available.

1.1.3.Study Area

The research area is the city of Tashkent, a capital of the lower middle-income country Uzbekistan. Uzbekistan is one of the landlocked countries situated in Central Asia (Figure 1), with a total area of 447,400 km2. The population of Uzbekistan is 31.3 million with a yearly growth rate of 1.3 per cent in 2016[2]. Tashkent is the capital and the largest city of Uzbekistan with a population of 2,309,300 people. Water management has become a major problem in the development of Uzbekistan. Freshwater resources there consist of a surface flow of rivers, glaciers, groundwater, lakes and reservoirs. However, almost 90% of the water resources of mountain basins, located in the territories of neighboring states (World Bank, 2009).

Ninety-three per cent of the water taken from surface sources is used for the purposes of the agricultural sector. Meanwhile, in the city of Tashkent, average water consumption per capita is 400 litres per day (World National Consultation, 2015). The total amount of water consumption by the population of the city is 754 million m3 annually. 3/4 of the volume of water supplied to the city comes from public sources via the Bozsu channel (Suvsoz, 2016). The city of Tashkent is provided with water via seven water intake structures and most of them have been operating for more than 40-45 years: large water intake facilities include Bozsu, Kibray, South water intake facilities, Kadiri, while small water intake facilities comprise Kara-su, Sergeli, Bektemir (Suvsoz, 2016).

Figure 1 Republic of Uzbekistan (adapted from http://www.portalsaofrancisco.com.br)

[2]Worldometers (2016) Uzbekistan Population (live), Uzbekistan, last modified December 16, 2016, retrieved from http://www.worldometers.info/world-population/uzbekistan-population/

1.2. Aims and Objectives

Considering the absence of data on both the concentration of *Cryptosporidium* in potable water and treatment against *Cryptosporidium* in Uzbekistan and the impossibility of citizens of the city of Tashkent to drink water directly from the tap, the following aims are defined:

(1) to propose solutions to improve the microbiological drinking water quality in the city of Tashkent; and
(2) to assess costs and benefits of the most applicable water treatment method

The following research (sub-)questions have been formulated to support the objectives above:

i. What is the human health risk of drinking tap water in the city of Tashkent?
   a. What are the concentrations of *Cryptosporidium* in the surface water for drinking?
   b. What is the exposure of the population of Tashkent to *Cryptosporidium* from surface water?
   c. What is the dose-response relationship between *Cryptosporidium* and health problems?

ii. What are the costs and benefits to use the most effective water treatment method in the city of Tashkent?
   a. What are water treatment methods applicable to be used in the city of Tashkent?
   b. What are the average costs of medical treatment of a person holding Cryptosporidiosis?
   c. How many disability-adjusted life-years lost due to watery diarrhoea in the city of Tashkent in 2016?

1.3. Outline

This thesis divided into two parts. Part I focused on achieving the first aim of the research with the support of Quantitative Microbial Risk Assessment and Part II dedicated to the second aim via Cost Benefit Analysis. Both parts starts with materials and methods used. Followed by results that demonstrate that the set aims are achieved. Each research (sub-) questions are answered in structured order. Part I shows the human health risk of drinking tap water in the city of Tashkent. Then, in combination with literature reviewed and conducted QMRA in Part I, the most applicable water treatment method is chosen to proceed further research and calculations in Part II. That Part II gives the results on the costs and benefits to use the most effective water treatment method in the city of Tashkent. Finally, results of both Part I and Part II combined and briefly discussed. Based on that conclusions are given to propose solutions to improve the microbiological drinking water quality in the city of Tashkent; and show costs and benefits of the most applicable water treatment method.

PART I: Human health risk of drinking tap water in the city of Tashkent

2.1. Material & Methods

2.1.1. Quantitative Microbial Risk Assessment

The main part of the research is structured according to QMRA. QMRA is implemented as a tool to evaluate the risk related to Cryptosporidium emissions in water supply for those who live in Tashkent. A community portal for the QMRA field3 defines it in the following way: "QMRA is a framework and approach that brings information and data together with mathematical models to address the spread of microbial agents through environmental exposures and to characterize the nature of the adverse outcomes". In short, QMRA is used to identify where microbes can become hazardous and help to estimate the human health risk by taking into account all the uncertainties. To calculate QMRA, this research goes through the following stages (Figure 2):

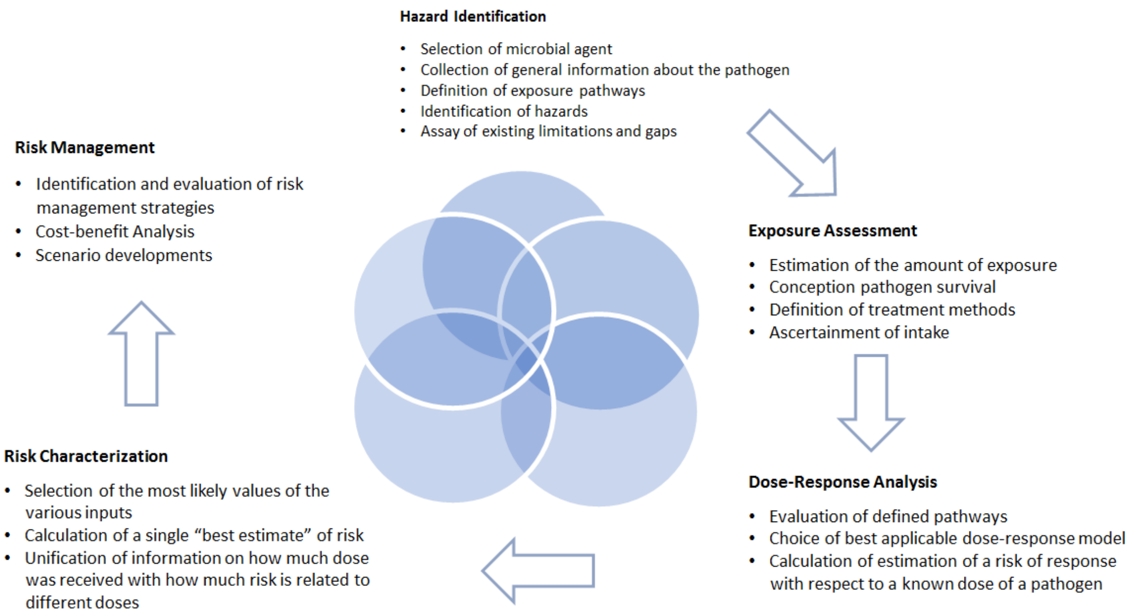

Figure 2. QMRA framework step by step (Adapted from: Medema, 2010 and qmrawiki.canr.msu.edu)

The above-given figure demonstrates five stages that must be passed to complete the quantitative microbial risk assessment. The first stage called Hazard Identification starts with the selection of microbial agents, which could be pathogens. After the actual choice, the discussion on the venues, situations, and problems needs to be proceeded, which includes a list of related hazards. Also, pathways of exposure of the chosen microbial agent are defined. It is important to assay existing limitations and gaps, e.g. not enough of data. As there is no

[3] WikiQMRA (2016) Quantitative Microbial Risk Assessment , Last modified November 17, 2016, Retrieved from http://qmrawiki.canr.msu.edu/index.php/Quantitative_Microbial_Risk_Assessment_(QMRA)_Wiki

data available on the concentration of the hazard, in that case, Global Waterborne Pathogen model (GloWPa) is used to identify the concentration level of the oocysts of Cryptosporidium in drinking water in the city of Tashkent.

2.1.2. Global Waterborne Pathogen model

As the main research instrument of the hazard identification stage, GloWPa developed by Hofstra (2016) is applied and is adjusted for being used in a basin level to identify the concentration level of *Cryptosporidium* in Tashkent. The model calculates human and livestock emissions of *Cryptosporidium* to the surface water (Hofstra et al., 2013). The model provides a map for *Cryptosporidium* emissions at 0.5 by 0.5-degree resolution, the grid value is taken for the grid covering of the city of Tashkent. The model takes into account both nonpoint (animals) and point sources (humans) of *Cryptosporidium* emissions. The model is programmed in R. For this study human inputs and livestock that produces *Cryptosporidium parvum* that can infect humans (cattle, sheep, goats, etc.) have been included. The following Figure 3 demonstrates more detailed idea about how the GloWPa model operates:

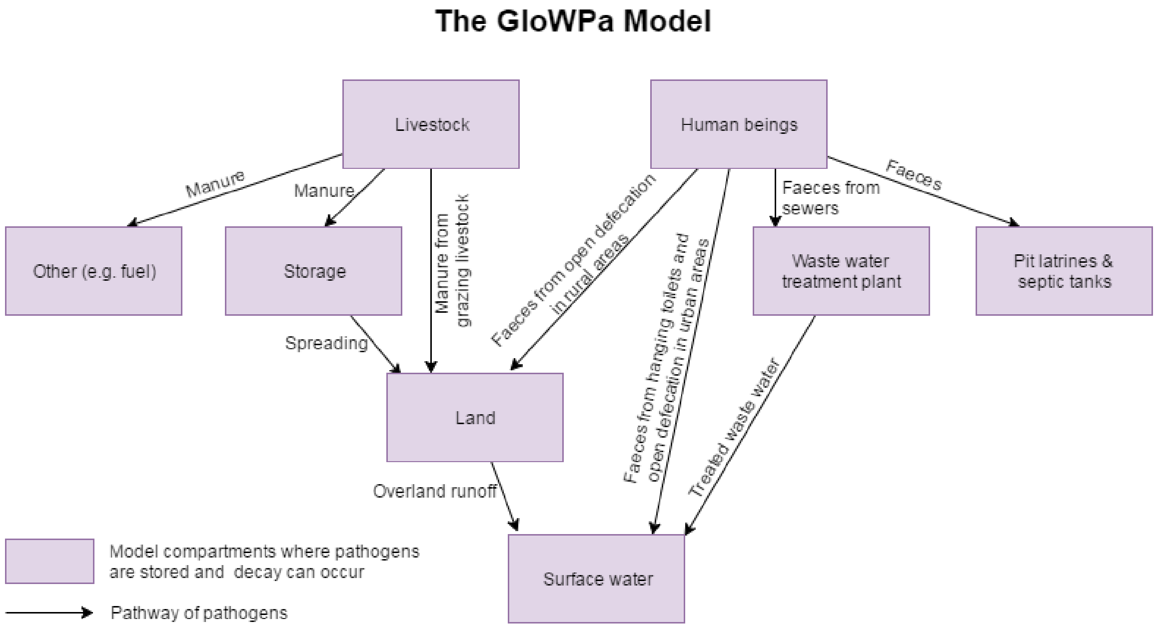

Figure 3. Conceptual framework of *Cryptosporidium* emissions from humans and livestock to surface water (adapted from: Hofstra, 2013).

Here non-point emissions are emissions by animals. Animals are taken into account since emissions made by them are transmitted over agricultural lands and possibly enter the surface water via runoff (Hofstra et al., 2013). Point source emissions are considered as emissions made by humans that go to the surface water through sewage systems. The emission models for human and livestock have been coupled to a hydrology model and concentrations have been calculated. Concentrations have been modelled for 12 months in approximately the year 2010. For this study, an annual average of the monthly values has been used as input. For this research, a very first set of concentration estimations is used because the final set is not yet available. Concentrations are very uncertain still and have not been validated.

2.1.3. Exposure Assessment

The second stage is Exposure Assessment. Originally, Exposure Assessment comes right after Dose-Response Analysis (Medema et al., 2004). The reason for swapping these two stages is that to determine how much water must be consumed to become ill, it is necessary to define how much water people consume as a whole. The exposure assessment is dedicated to defining how much water is daily ingested, what treatment methods exist and how effective they are. There is a necessity to estimate the amount of exposure. The goal of the exposure assessment of QMRA is to appraise the importance and frequency of exposure to pathogens through the identified exposure pathways. The exposure assessment is based on the following two factors (World Health Organization, 2016):

- Concentration of *Cryptosporidium* oocysts in consumed drinking water; and
- Consumption of drinking water without home remedies

The exposure of humans to *Cryptosporidium* starts when the ingested oocysts release sporozoites, which invade the epithelial cell of the intestinal (Leav et al., 2003). In the case of *Cryptosporidium*, Medema, (2009) defines the exposure as “a single dose of one or more *Cryptosporidium* oocysts that a consumer ingests at a certain point in time, or the total amount of oocysts that constitute a set of exposures, i.e. over a day or a year”. The identification of the exposure of the population of Tashkent to *Cryptosporidium* from surface water involves consideration of the transport and survival of *Cryptosporidium.* Also, the assumption must be done on how much drinking water is consumed per person per day.

2.1.4. Dose-Response Analysis

Next, the dose-response analysis will be calculated. There are two main full single-hit dose-response models: Beta-Poisson Model and Exponential Model. However, also other models exist, such as fractional Poisson, exponential with immunity, hierarchical Beta-Poisson, hierarchical logistic (Messner et al., 2001), etc. QMRA specialists recommend different models. For example, to calculate the probability of infection by *Cryptosporidium* in drinking water, Medema (2009) and Xie et al., (2016) recommend the Beta-Poisson model. Meanwhile, Messner, Chappell, and Okhuysen (2001) claim that the Exponential model is the simplest one-parameter model. For the dose-response analysis of this research, the Beta-Poisson model is chosen to be used and is focused on the city of Tashkent only.

Beta-Poisson dose-response function

The Beta-Poisson model brings variability to the relationship between the host and the pathogen and it let the exponential dose–response parameter vary from host to host as a beta random variable (Messner & Berger, 2016). The model has two parameters α and β. The Beta-Poisson model has the same following assumptions, with additional two:

- Probabilities of survival and being infected are not constant; and
- Probabilities of survival are based on the best distributions

The formula of Beta-Poisson model is the following [1]:

$$P\,inf = 1 - \left[1 + \frac{dose}{\beta}\right]^{-\alpha} \qquad [1]$$

Thus,

Pinf = the probability of infection which is a function of *d, α,* and *β d* = mean absorbed dose

β= a slope parameter, which holds when *β≥1* and *α≤β α* = a slope parameter

To calculate the Beta-Poisson relationship for *Cryptosporidium*, *α* = 0.115, *β* = 0.176 parameters are used (Smeets et al., 2007). To calculate the Beta-Poisson distribution concentration level is converted to litres , therefore, the average concentration level is divided by 1000.

To calculate risk for being infected by *Cryptosporidium* the further steps are done. First, the data on the concentration is generated with taking into consideration uncertainties possibly appear throughout the calculation. For concentration data generation mcstoc R package is used with normal distribution of mean of the concentration level of *Cryptosporidium* in the city of Tashkent retrieved from GloWPa model and standard deviation of 0.001. Also water intake is taken into account. For dose-response data generation, mcstoc R package is used with the Poisson distribution of lambda equal to exposure (concentration times intake). However, since concentration level based on GloWPa model is very uncertain, therefore a characterization by Medema et al (2009) is used. They identify from very pristine to grossly polluted areas (Table 5).

Table 1. Classification below the average oocyst concentration (adapted from Medema et al., 2009)

Very pristine	Pristine	Moderately polluted	Polluted	Heavily polluted	Grossly polluted
0.001	0.01	0.1	1	10	>100

As a result, in this research, the dose-response analysis demonstrates what is the human health risk of ingesting the particular amount of oocyst of Cryptosporidium. Firstly, the current conditions when Chlorination is used as the only water treatment method in the city of Tashkent is calculated to see what is the human health risk of ingesting the particular amount of oocyst of Cryptosporidium. Followed by calculation with reduction of the concentration level (in case if it is necessary) Ozonation and UV water treatments are applied. As regards, Risk characterization and Risk managements parts, they are researched in Part II of the study.

2.2. Literature review

2.2.1. Pathogens

Infectious diseases have been known to humankind since ancient times and remain a reason for the death of one-third of the world population, which is more than the cancer-based index in the mortality rate (Alberts et al., 2002). The huge territories were covered by epidemics/outbreaks of diseases, including entire regions and countries. The prevention of infectious diseases, as well as the fight against them, have been a common problem of people. Infectious processes are one of the most difficult biological processes in nature, and infectious diseases are terrible destructive factors for human society causing enormous pressure on livelihood. The process of infection is capable of taking all levels of an organism – organismal, fabric, cellular, molecular. There are two exits from an infectious state – lethal and an absolute recovery, or rather, a complete release of the body from the infectious agent. It is worth mentioning that full healing from the infection can only occur when the organism completely wins and gets rid of the activator. Since the mid-1800s, physicians and scientists have had difficulties in determining agents (pathogens) that cause infectious diseases (Alberts et al., 2002).

Currently, there are 25 known *Cryptosporidium* species (Cabada & White, 2016) and 16 of them are given in the following table:

Table 2 Cryptosporidium and Giardia as foodborne zoonoses

Species	Major hosts
Cryptosporidium hominis	Humans
Cryptosporidium parvum	Cattle, humans
Cryptosporidium muris	Rodents
Cryptosporidium suis	Pigs
Cryptosporidium felis	Cats
Cryptosporidium canis	Dogs
Cryptosporidium meleagridis	Turkey, humans
Cryptosporidium wrairi	Guinea pigs
Cryptosporidium bovis	Cattle
Cryptosporidium andersoni	Cattle, bactrian camel
Cryptosporidium baileyi	Poultry
Cryptosporidium galli	Finches, chicken
Cryptosporidium serpentis	Lizards, snakes
Cryptosporidium saurophilum	Lizards
Cryptosporidium scophthalmi	Fish
Cryptosporidium molnari	Fish

However, people are not vulnerable to all genotypes of the parasite. Dillingham et al.,(2002), Fayer et al., (2000), Hofstra et al., (2013) state Cryptosporidium parvum and Cryptosporidium hominis are the main hazardous genotypes to human beings. But

Cryptosporidium muris, Cryptosporidium cuniculus, and Cryptosporidium andersoni are also pathogens dangerous to humans that have been recognized recently. In this research, the focus will be only on Cryptosporidium parvum and Cryptosporidium hominis. The largest waterborne disease outbreak was registered in 1993 in that affected 403,000 people in only 2 weeks of time (Mac Kenzie et al., 1991). The Figure 4 below shows pathway and influencing factors of Cryptosporidium oocysts to create a risk of people being infected (Bozzuto, 2010):

Figure 4. Pathway and influencing factors of Cryptosporidium oocysts (adapted from Bozzuto, 2010)

World National Consultation (2015) states that in Uzbekistan the hydrological data is in open access to its basic customers. However, in reality, it was not easily possible to get data on water, as it was considered confidential information. In the case of Tashkent, as a travel advice4 said that water is not safe to drink there and that tap water there should be determined as contaminated due to pollution caused by microorganisms which can lead to severe diarrhoea.

2.2.2. Dose-Response relation

Transmission of *Cryptosporidium* occurs by the fecal–oral route but possibly also occur by aerosols. *Cryptosporidium* lives in the intestine of both infected people and animals, and this parasite can be found in the stool of them (Centers for Disease Control and Prevention, 2016). *Cryptosporidiosis* is a diarrhoeal disease which is induced by *Cryptosporidium* (Chen, Keithly, Paya, & LaRusso, 2002), and watery diarrhoea accompanied by abdominal pains, nausea, flatulence or malaise is considered as the main symptom of *Cryptosporidiosis*. Other symptoms can include(Centers for Disease Control and Prevention, 2016) stomach pain, dehydration, vomiting, etc. The incubation period of being infected by *Cryptosporidium* is 1 - 14 days (Center for Food Security and Public Health, 2005; National Foundation for Infectious Diseases, 2008), with 7 days on average.

A person can be infected by just accidentally ingesting the parasite, for example, swallowing something that was in contact with the stool of someone infected or drinking recreational water contaminated with *Cryptosporidium* while swimming, or intentionally drinking water from the tap, which may be contaminated. However, *Cryptosporidium* cannot be disseminated by contact with blood (Centers for Disease Control and Prevention, 2016). Another essential point is diagnosing *Cryptosporidiosis*, which can be intricate and laborious

[4]Division of the Foundation for the Support of International Medical Training, Country Health Advice Uzbekistan, Last modified December 10, 2016, Retrieved from https://www.iamat.org/country/uzbekistan/risk/food-water-safety-overview

because *Cryptosporidium* is very small and difficult to reveal under a microscope. Besides, it is usually based on testing several samples of stool over a certain period of time, however, it can be only several days, but still, the diagnosis can be considered as reliable (National Foundation for Infectious Diseases, 2008).

For a specific group of vulnerable people, Cryptosporidiosis can possibly have a fatal outcome. The group vulnerable to *Cryptosporidium* includes children between 1 and 5 years old*,* the elderly (Public Health Agency, n.d.) and people with immune system problems (Chen, Keithly, Paya, & LaRusso, 2002; Leav et al., 2003). Also, those who care for or work with vulnerable groups are also in danger of being infected. People with immune system problems include patients with HIV/AIDS, congenital immunodeficiency and people who experienced organ, tissue or other body cells transplantation for therapeutic purposes.

Statistically, every year, over 1.4 million children die from diarrhoea transmitted by unclean water, which is equal to 4,000 child deaths per day or a single child death every 20 seconds (Haruna & Rahman, n.d.). Meanwhile, according to the Sanitary and Epidemiological Station of the Republic of Uzbekistan, in 2015, 7151 inhabitants of Tashkent were hospitalized with watery diarrhoea, and in 6609 cases the etiology of watery diarrhoea was not defined. Since *Cryptosporidium* in Uzbekistan is not measured, in this research it is assumed that the unknown etiology of the sickness by diarrhoea is the symptom of *Cryptosporidiosis*. The table below shows a correlation between the number of those hospitalized with watery diarrhoea and the number of oocysts of *Cryptosporidium* in surface water.

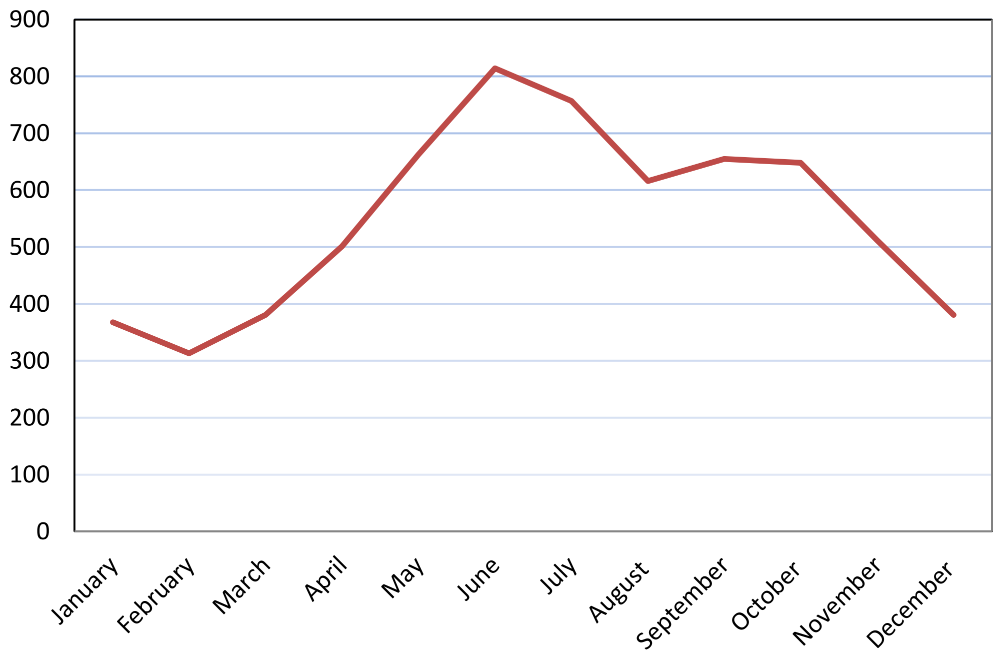

Figure 5. Number of inhabitants hospitalized with watery diarrhoea for 2015

Interestingly, Figure 5 demonstrates that while the concentration level of oocysts of Cryptosporidium in surface water was low, the number of complaints on water diarrhoea to hospitals increased gradually and reached a peak in June. The pie chart in Figure 6 illustrates the number of inhabitants hospitalized in Tashkent in 2015 based on their age range. It is clear that patients aged 0 - 1 and those aged 2 - 3 made up the highest proportions, both one third. However, with reference to the Sanitary and Epidemiological Station of the Republic of Uzbekistan5, no people died because of diarrhoea in 2015.

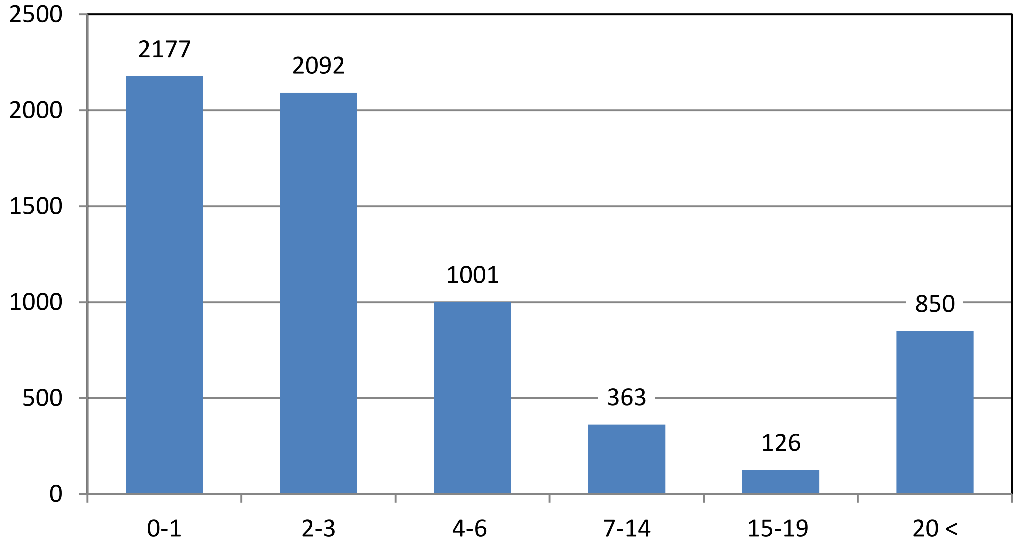

Figure 6. Amount of hospitalized inhabitants according to age in 2015

[5]Data on diarrhoea for 2015. Sanitary and Epidemiological Station of the Republic of Uzbekistan, not available online.

2.3. Results

2.3.1. Concentration of *Cryptosporidium* in the surface water for drinking

The concentration in drinking water is derived from the GloWPa model. For that, R was used. First of all, to get the map of concentrations GPS coordinates was found. The results show that the latitude coordinate and the longitude coordinates of Tashkent are approximately 41.29 and 69.25 respectively. The concentration for the beginning of the year (January) and the end (December) are assumed to be almost identical. However, the maps (Figure 7) on concentrations give only approximate results which vary between log6 and log7 oocysts/m^3 (red square).

The output of the GloWPa model is shown in the form of average loads and concentrations for every month. Loads are the total number of oocysts transported with surface water in a grid cell from January till December.

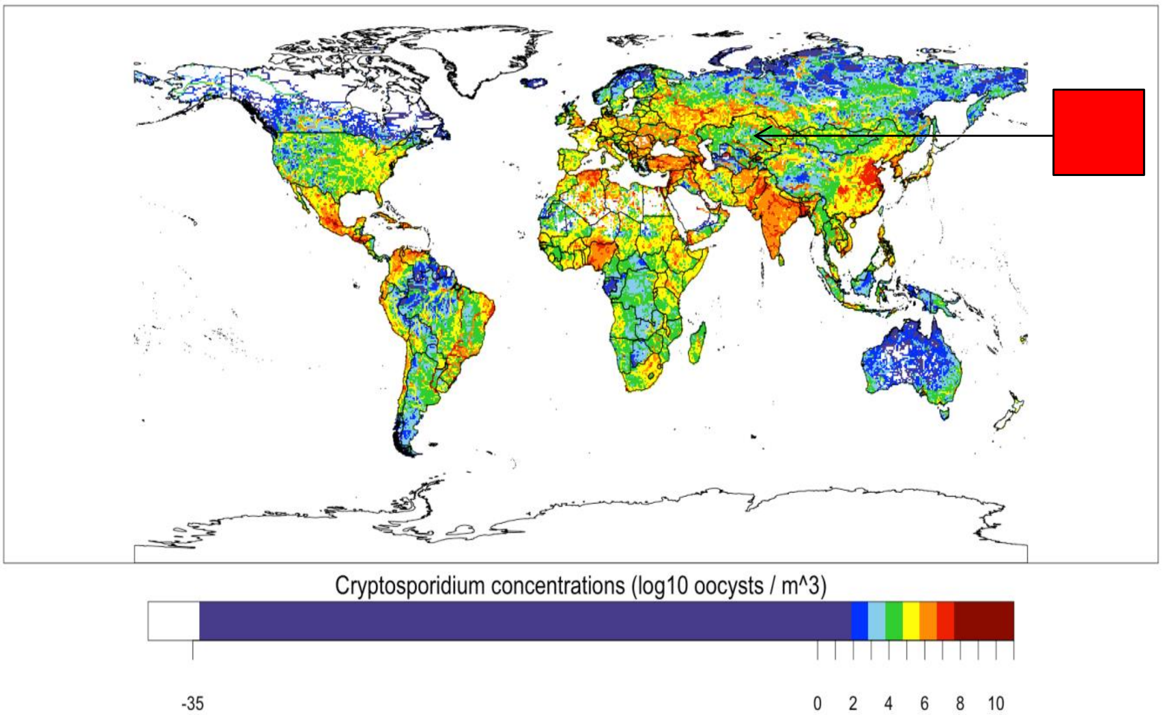

Figure 7. *Cryptosporidium* concentrations according to GloWPa model

As the average concentration level of Cryptosporidium in Tashkent city is equal to 3.9 $\log_{10}$ per litre, that makes clear that water quality in the city is between polluted and heavily polluted (Table 5). The grossly polluted areas are described to be huge urbanized areas with intensive agriculture in the watershed (Medema et al., 2009).

Concentrations are load divided by the monthly river discharge (oocysts/m3). Figure 8 below demonstrates how the concentration level changes throughout the year in the city of Tashkent in 2015. The peak of 14000000 oocysts which is equal to 7.2 logs was reached in September. The reason for the sharp decline during the period from March to May is unknown and assumed to be inaccuracy in modeling results of GloWPa for this particular area.

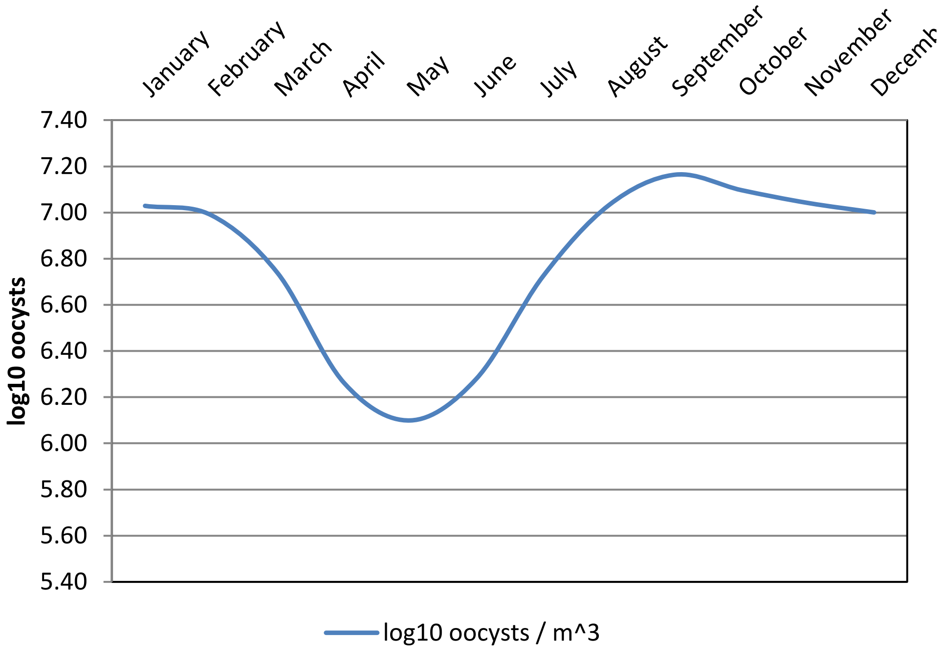

Figure 8. Annual *Cryptosporidium* Concentration Level in the city of Tashkent in 2015

2.3.2. Exposure of the population of Tashkent to *Cryptosporidium*

The first-hand data on how much water people consume in Tashkent is not available, therefore, the research can be based on the secondary data. Rose, Haas & Regli, (1991) and World Health Organization (2016) assume that on average, a person consumes 2 litres of water per day while others claim that a person drinks one litre per day (Howard, Pedley & Tibatemwa, 2006). As Tashkent is a big city with available water facilities, it can be assumed that the average daily water consumption of tap water is two litres per capita would be an idealistic situation. However, to calculate the exposure to contaminated water, the context of intake is defined as intentional drinking, unintentional ingestion, aerosol ingestion or through food consumption (Haas, Rose & Gerba, 1999). In this research, the assumption made that exposure of the population of Tashkent to *Cryptosporidium* from surface water is 2 litres per day.

2.3.3. Dose-response relationship between Cryptosporidium and health problems

To calculate the Beta-Poisson distribution concentration level is converted to litres , therefore, the average concentration level is divided by 1000 and equals to 3.9 $\log_{10}$. Also, it is necessary to mention that the calculations were done first with taking into account uncertainties, however, as the results on Beta-Poisson distribution was giving an error, it was decided to generate the model without uncertainties too (Figure 9). According to the results of calculation, the daily risk of infection is equal to 0.355 $(person^{-1}d^{-1})$ with dose of 3.9 $\log_{10}$ per litre, which is considered to be high. Meanwhile the yearly risk of infection is 1

($person^{-1}yr^{-1}$) with both taking into account uncertainties, and without. Which means every person in the city of Tashkent gets infected by *Cryptosporidium parvum* at least once per year. As it is mentioned above *Cryptosporidium* is resistant to Chlorine, and exactly that water treatment is used in Tashkent city therefore, the, result of application of the the Chlorine is considered as business as usual. However, removal for Ozonation is 1.5 $\log_{10}$ and Uv is 3.0 $\log_{10}$ with taking into account uncertainties in the calculation showed slightly different outcomes. Results for Ozonation says that even though the concentration is reduced by 1.5 $\log_{10}$ the daily risk is equal to 0.319 ($person^{-1}d^{-1}$), while the change of being infected per year is still equals to 1 ($person^{-1}yr^{-1}$) without uncertainties, and , which mean the chance that again everybody would get infected by oocysts of *Cryptosporidium.* But with taking into account uncertainties in the calculation, the concentration level will go down with the chance of being infected per year is 0.992 ($person^{-1}yr^{-1}$).

Meanwhile, results with taking into account uncertainties in the application of UV demonstrates that the concentration level is reduced by 3.0 $\log_{10}$ and makes daily risk equal to 0.242 ($person^{-1}d^{-1}$), while yearly risk of being infected per year is 0.834 ($person^{-1}yr^{-1}$), which means that still the chance that everybody gets infected is very high. But the calculation without taking into account uncertainties is 1 ($person^{-1}yr^{-1}$). The manual calculation gives the same results, that using water treatment methods as Chlorine, Ozonation and UV are not effective enough. As a result, it is clear that after application of any of the above-mentioned methods already the daily risks of infection for *Cryptosporidium* exceeded the annual acceptable risk of 0.0001.

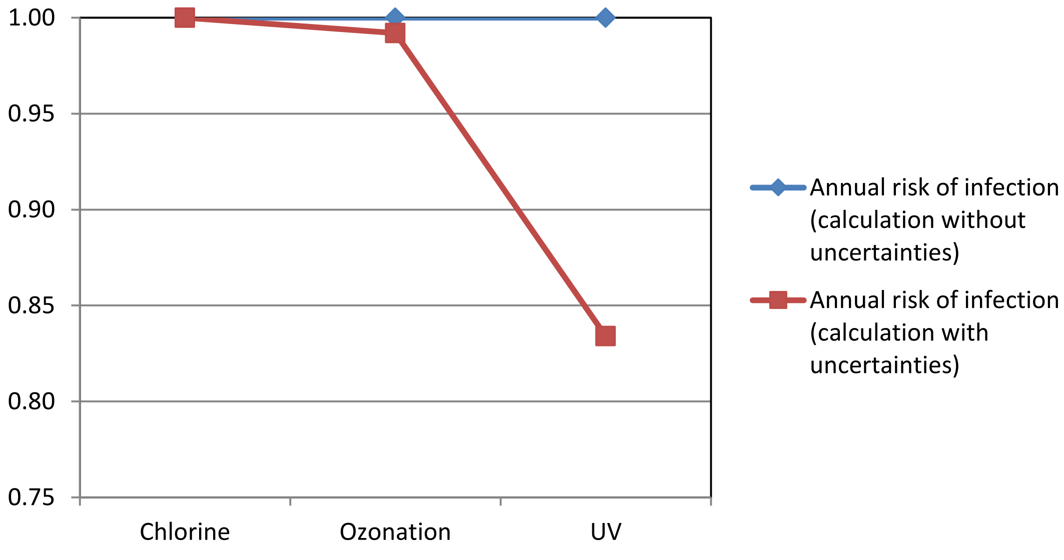

Figure 9. Calculated annual risk of infection by *Cryptosporidium* (with and without uncertainties)

However, if it is already admitted that the results of GloWPa on *Cryptosporidium* concentration are very uncertain, thus it is decided to make the calculation in the case of the concentration level of *Cryptosporidium* in drinking water is 100 oocysts per litre, which still means that water is grossly polluted. The calculations gave the result that if the concentration level is 2.0 $\log_{10}$, then the use of UV is still not applicable since the concentration level would not be lower than the annual acceptable risk of 0.0001, while treatment with Ozonation is also not effective enough.

PART II: Costs and benefits to use the most effective water treatment method in the city of Tashkent

3.1 Material & Methods

In combination with literature reviewed and conducted QMRA in Part I, the most applicable water treatment method is chosen to proceed further research and calculations in Part II.

3.1.1. Average costs of medical services

First of all, the amount of a course of medical treatment is calculated, that gives an idea how much medical services costs for a single person who lives in the city of Tashkent to be treated from watery diarrhoea. The calculation includes one bed-day expense. Bed-day means the occupancy of a bed at the hospital by a patient for one day. To do that these variables are taken into account:

1. Salary of medical personnel:

- Doctor's consultation + Treatment assignment + Monitoring a patient for 7 days

- Implementation of healthcare instruction of a nurse

- Nursing care by a junior nurse

2. Diagnostic testing

3. Dietary food for the course of a medical treatment

4. Necessary medical supplies for the treatment of watery diarrhoea

For the calculation of overhead expenses the following formula is used in Uzbekistan based on Order number 526 of Ministry of Health of the Republic of Uzbekistan Order on "Approval of the procedure of formation of tariffs for paid services and the list of paid medical services rendered to the population of the Republic of Uzbekistan Ministry of Health medical institutions" (Appendix A). Thus [2]:

$$HP = \frac{ФЗП_{АУиХП} + (IV_{гр} - (M + П + MO + KP))}{ФЗП_{ОП}} \times 100\% \qquad [2]$$

Where,

HP - overheads;

$ФЗП_{АУиХП}$ - Wages-fund of administrative and commercial staff + social security contributions;

KP - costs of major repairs;

IVгр. - IV group of expenses (other expenses);

M – costs on medicines;

П. - food costs;

MO - acquisition of fixed assets;

ФЗП оп+отч - Wages-fund of key personnel + contributions;

All the expenses are calculated in the currency of Uzbekistan - Uzbekistan Sum (UZS) and converted to € according to the current exchange rates. Since currency rates change every day, it will be approximate for the day research will be read.

3.1.2. Disability-adjusted life years

DALY is a common metric unit that takes into consideration various probabilities, severities and time span of effects of health hazard, in this case by *Cryptosporidium*. This metric is developed for being used in WHO Guidelines for Drinking Water Quality. The principle of the DALY is to evaluate and assess health effects of particular hazards. The severity of the effects varies from 0 (normal or good health) to 1 (lethal outcome). With the reference to Highfill & Bernstein (2010), one DALY represents the loss of one year of equivalent full health. Then it takes into account the duration of the effect, a number of people who are affected. After that, all the valid parameters can be summed. To that years lived with disability (YLD) and years of life lost (YLL) are added and that gives DALY (Vijgen, Mangen, Kortbeek, Duijnhoven, & Havelaar, 2007). Thus [3]:

$$DALY = YLD + YLL \qquad [3]$$

Gorchev & Ozolins (2011), the tolerable burden of disease is 10−6 DALY per person per year. The tolerable burden of disease is the highest limit of health effects burden by waterborne disease (Gorchev & Ozolins, 2011). In this calculation of DALY social value weights that includes age-weighting and discounting wage not be taken into account. The general formula of *YLL* is [4]:

$$YLL = N\ x\ L \qquad [4]$$

here *N*=number of deaths, and *L*=standard life expectancy at the age of death. As regards *YLD*, it has the following way of calculation [5]:

$$YLD = P\ x\ DW \qquad [5]$$

Where *P*=number of cases and *DW*=disability weight. DW here is a factor that shows the severity of the disease.

Firstly, DALY per case will be found, followed by that for per 1000 case and for the sum of those who get infected. That will be calculated by dividing total number those who get infected and have watery diarrhoea by 1000, then multiplying it with DALY per 1000 cases. That will show how many DALYs could be saved if the drinking water would be treated effectively. Also, further to give a cost per DALY, the total cost of medical treatment for all cases will be divided by the sum of the DALYS of those who could be treated (McCord & Chowdhury, 2003). This number will show how cost effective would each DALY averted.

3.1.3. Cost-Benefit Analysis

Cost-Benefit Analysis is a tool that estimates and sums up the equivalent money value of all costs and possible benefits of the particular activity (e.g. installation of water treatment system) to identify if it is profitable (Dreze & Stern, 1987).

When he most effective water treatment is defined, the average cost of its installation is calculated. Since costs and benefits vary throughout the time period, their present value must be calculated first. The general formula of present value [6]:

$$PV = \frac{\mathrm{CF}}{(1+r)^n} \qquad [6]$$

Where,

CF – cash flow in future period

r – discount rate

n – number of periods

According to (Blas, 2006), the Net present value is "The present value of an investment's expected cash inflows minus the costs of acquiring the investment" with the formula [7]:

$$NPV = (Cash\ inflows\ from\ investment) - (cash\ outflows\ or\ costs\ of\ investment) [7]$$

This calculation demonstrates if the initial investments add value to the investors. The inflation rate in Uzbekistan equivalents to 0.07. The calculation of initial investment is done via taking into account number of families live in the city of Tashkent, and with an assumption that filters will be installed in each household. The reason of that is there is no data provided on size, location, and capacity of water treatment plants of the city of Tashkent. World National Consultation (2015) states that in Uzbekistan the hydrological data is in open access to its basic customers. However, in reality, it was not easily possible to get data on water, as it was considered confidential information.

When initial investment that must be done by SUE "Suvsoz" to effectively treat the drinking water from *Cryptosporidium* is calculated, further research is focused on the calculation of payback period. To estimate that payback period for initial investment on installation and use of the most applicable water treatment method, four scenarios are developed based on the cost of medical services. Scenarios show what behavior of people can be expected in taking medical treatment in case of watery diarrhoea which is a consequence of Cryptosporidiosis. When scenarios are developed, the most real scenario is chosen, and the payback period is adjusted.

3.2. Literature Review

3.2.1. Treatment efficacy

First of all, to clearly define the amount of the disinfectant required to inactivate microbial protozoa, the Environmental Protection Agency (EPA) has determined Ct Values. Here, C means a residual disinfectant concentration expressed in mg per litre and t which is the corresponding contact time expressed in minutes (Siemens, 2009). These Ct Values are disclosed to a logarithmic scale (log scale) that can be transformed into percentage without difficulties (e.g. 1 log reduction = 90% reduction, 2 log reduction = 99% reduction, 3 log reduction = 99.9% reduction). Based on the findings of Leav et al. (2003), there is still no accord between scientists and public representatives regarding the safe limits of *Cryptosporidium* protozoa in drinking water supply. Meanwhile, it is suggested by Haas & Eisenberg, (2001) an annual risk of infection from *Cryptosporidium* in drinking water equals to 0.0001 is admissible, or on the other words one infection per 10,000 individuals per year. Rose et al., (1996) claims that 3.17 log reduction is necessary for *Cryptosporidium.* Complementary to this, U.S. EPA (2005) reported that filter water systems with higher treatment categories must provide at least 90 per cent up to 99.7, which are 1.0 to 2.5-log additional inactivation in the case of *Cryptosporidium.* However, all unfiltered water system results must provide at least 99 or 99.9 per cent which are 2 or 3-log reductions of *Cryptosporidium* (U.S. EPA, 2005). All decisions on the strength of treatment must be dependent on monitoring results of drinking water.

Here, are different methods to purify drinking water. One of the most effective ways can be considered is chemical disinfection, however, *Cryptosporidium* oocysts are resistant to disinfectants (including chlorination), as well as to changes in the environment. This natural resistance of *Cryptosporidium* oocysts is an obstacle to the ideal water treatment in sewage treatment plants. According to UISCE & Irish Water (2016) disinfection from *Cryptosporidium* by Chlorine, chloramines, Chlorine dioxide gives poor results. Table 3and Table 4 below show Ct Values (mgCmin/L) for *Cryptosporidium* inactivation by Chlorine dioxide and ozone respectively:

Table 3. Chlorine dioxide Ct Values for *Cryptosporidium* (adapted from Debrum, 2012)

	Log Credit	**Water Temperature, °C**				
		10	15	20	25	30
Chlorine Dioxide	0.5	138	89	58	38	24
	1.0	227	179	116	75	49
	2.0	553	357	232	150	98
	3.0	830	536	347	226	147

Table 4. Ozone Ct Values for *Cryptosporidium* (adapted from Debrum, 2012)

	Log Credit	Water Temperature, °C				
		10	15	20	25	30
Ozone	0.5	4.8	3.1	2.0	1.2	0.78
	1.0	9.9	6.2	3.9	2.5	1.6
	2.0	20	7.8	7.8	4.9	3.1
	3.0	30	12	12	7.4	4.7

With reference to Debrum's (2012) Table 2 shows that Chlorine dioxide requires a Ct of 226 mg/L at one minute of contact time, at 25°C to achieve a 3-Log reduction. Meanwhile, Table 3 and 4 demonstrate that water treatment by ozone and ultraviolet light irradiation give good results (Treatment, 2016). The log inactivation for *Cryptosporidium* by Ozone requires a Ct of 7.4, correlating to 7.4 mg/L, to achieve a 3-Log reduction with the same parameters as Chlorine dioxide. (Waterloo University, 2014) claims that ozone is a strong disinfectant that reduces protozoa in case sufficient doses and contact times are applied. As regards ultraviolet (UV) germicidal sterilizer, it produces UV light at the 254-nanometer wavelength. As a result, it battles microbes by scrambling the DNA and RNA (World Health Organization & IWA, 2004). Drinking water moves through the UV sterilizer and passes protected by a quartz sleeve - the UV light. Table 5 shows the dose rate that determines an effective log reduction. All values are presented in mJ/ cm^2.

Table 5. UV Ct Values for *Cryptosporidium* (adapted from Debrum, 2012)

	Log Credit	Log Inactivation
UV	0.5	4.8
	1.0	9.9
	2.0	20
	3.0	30

Also, Connelly et al., (2007) gives the evidence that natural UV radiation is able to significantly reduce *Cryptosporidium* parvum. They claim that during the summer period means infectivity can be reduced by an average of 67% and >99.99%, respectively. Also, one minute of heating water to 72°C degrees can make it non-infectious (McAuley et al., 2012). However, it is necessary to note that Waterloo University (2014) suggests that even though water treatment plants operate at a very good level, it cannot be ensured that potable water will be completely clear from *Cryptosporidium* oocysts. The above-mentioned methods are only able to reduce the number of oocysts, but cannot completely remove *Cryptosporidium* from the water supply (Leav et al., 2003). Even though the effectiveness of the approaches like UV and Ozonation are considered higher, these methods are not often applied due to financial matters and health-related concerns (Rose, Huffman, & Gennaccaro, 2002). In the study by the Centre International de Recherche sur l'Eau et l'Environnement (CIRSEE) (2016) and Medema (2009) generic log10 removals were assigned to Chlorination, Ozonation and Direct filtration UV water treatment methods (Figure 10) under the assumptions with "firstly, generic log10 removals described the treatment performance at each site adequately and secondly, performance of treatment processes is constant and independent" (Medema, 2009).

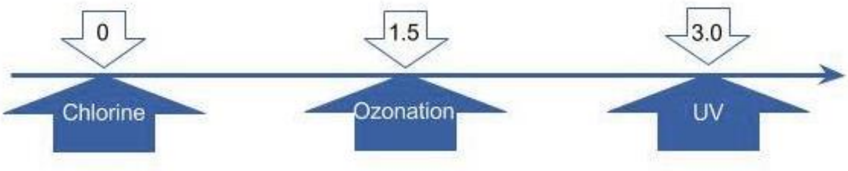

Figure 10. Log10 removals for *Cryptosporidium* reduction by treatment processes (adapted from Medema, 2009)

As it is mentioned, in the case of the city of Tashkent, to purify water, SUE "Suvsoz" uses liquid Chlorine and sodium hypochlorite. Indeed, Chlorine assuages all types of microbial waterborne pathogens like protozoa, viruses, and bacteria. White (2010) confirms that Chlorine is present in most disinfected drinking water with concentrations of 0.2–1 mg/litre. In one of the largest water intake facilities Bozsu, the water intake facilities completely abandoned the use of liquid Chlorine. Bozsu uses a safer substance which meets modern requirements - sodium hypochlorite (Centers for Disease Control and Prevention, 2016; Research Institute of Sanitation Hygiene and Occupational Diseases of Ministry of Health of Uzbekistan, 2006) However, both methods do not eliminate *Cryptosporidium* and some other microscopic organisms (Daniels and Mesner, 2010), with the *Cryptosporidium* protozoan parasite being one of the main causes of diarrhoea worldwide (Hofstra, 2013). Notwithstanding, according to (ECU & WHO, 2010), the chlorination of drinking water led to a reduction of incidences of diarrhoea by 62 per cent in Uzbekistan. This leads to the conclusion that a significant proportion of cases of diarrhoea in households with centralized water supply is related to the use of contaminated drinking water in the distribution system. As it is mentioned that *Cryptosporidium* is resistant to chlorination, therefore, the focus of *Cryptosporidium* removal are two types of water treatment: Ozonation and UV sterilizers. Medema (2009) clearly supports *Cryptosporidium* removal by water treatment in case of log10 reduction with 1.5 logs 10 for Ozonation and 3 logs 10 for UV. Indeed, 0 log reduction by Chlorination

3.3. Results

At the start of research, it was admitted that the concentration level of *Cryptosporidium* in drinking water in the city is based on the results of the GloWPa model which is 3.9 $\log_{10}$ per litre. Based on literature review two water treatment methods were chosen to be analyzed. Thus, dose-response analysis gave the results that UV and Ozonation water treatments are not effective enough to treat drinking water from oocyst of *Cryptosporidium*. But since the results of the GloWPa model are uncertain, it is assumed that UV is effective, since according to the literature review and dose-response analysis it has the highest reduction compared to Chlorination and Ozonation. The Part II of the study is based on the hypothetical situation where UV is effective enough to reduce the concentration level of *Cryptosporidium* in the city of Tashkent and it is focused to develop a basic and constructive structure for more precise research.

3.3.1. Average costs of medical services

To calculate the amount spent on the treatment of one patient with watery diarrhoea the following steps are done:

1. First of all calculation of a doctor's the salary is done (Table 6). That specialist sets inspection plan and properly and individually pick up medicine required for a patient. To proceed calculation when calculating the salaries (Appendix A) categorization of a specialist is taken into account. In the case of a doctor of infectious diseases, the category will be the highest – 9^{th} rank. Minimum wage in Uzbekistan for 2016 that equals to 149,775 UZS multiplied by a coefficient of 6.872.

149775 x 6,872 = 1029254 + continuous medical experience

If experience is over 20 years - 20% is added to the salary. Also, occupational hazards also are taken into account. Occupational hazards contain work in an infectious diseases hospital (15% is added to the salary). Next, the salary of a nurse is calculated. A nurse takes part in the implementation of all the manipulations (intramuscular, intravenous, intravenous drip injection, as well as the distribution of tablet drugs). The calculation is made in a similar way (the highest category for a nurse is 5^{th} rank with a coefficient of 4.609. The same calculation is done for a junior nurse (2^{nd} rank with a coefficient of 3.464).

Also, following taxes are taken into account:

Indirect labor charges - 25%

Income taxes - 7.5%

Retirement fund -1,6%

Education Fund - 0.5%

Infrastructure - 8%

Travel fund- 1.4%

Table 6. Calculations results on overhead expenses

	Hospital (UZS)	Tests (UZS)
ФЗПау+хп	841,981.4	734453.0
Social security contributions	210,495.4	183,613.3
IV-гр	1,426,050.3	1,426,050.3
М	366,835.0	366,835.0
П	323,997.9	323,997.9
МО	31,979.3	31,979.3
КР	0.0	0.0
ФЗП оп+отч	3,159,617.0	3159617.0
НР	**55.6%**	**51.3%**

An average number of bed-days of a single patient: In the treatment standards of the Republic of Uzbekistan, on average - 7 days.

2. Diagnostic testing (UZS): Costs for all tests conducted by the detection of this disease (see Annex D).

3. Dietary food per course of a medical treatment (UZS): 9400 sums per day multiplied by 7 bed-days at the hospital.

4. Necessary medical supplies for the treatment of watery diarrhoea (UZS): Costs for the drugs needed for the treatment of this disease (see Annex E).

Table 7. Calculation results of the amount spent on the treatment per patient with watery diarrhoea

1 bed-day of a single patient (UZS)	Average number of bed-days of a single patient (days)	Sum of average number of bed-days (UZS)	Sum of diagnostic testing (UZS)	Dietary food per course of a medical treatment (UZS)	Costs for the medical supplies (UZS)	**Total for 7 days of treatment (UZS)**
52,646	7	368,523	468,882	65,800	221,375	**1,124,580**
Value of 1 € (€) in Uzbekistan Som (UZS) for December 2016						3,404.13
Minimum wage in Uzbekistan for 2016 (UZS)						149,775
Total amount spent on per course of a medical treatment (€)						341

I conclude that the annual amount of money spent on per course of a medical treatment for watery diarrhoea per person is 341 € (Table 7). However, in fact, bed days at the hospital and diagnostic testing for infectious diseases in Uzbekistan are for free for the citizens.

3.3.2. Disability-adjusted life years

Cryptosporidium highly leads to the burden of disease. Cryptosporidiosis lasts for 1-2 weeks, while gastroenteritis is 3-6 days. In the city of Tashkent and in general watery diarrhoea in average lasts for 7 days. Severity weight for death and water diarrhoea are already given in the literature with 1.0 and 0.067 respectively, and that numbers do not require additional calculations. There is only 1 lethal outcome is registered in available data for the city of Tashkent in 2015, therefore severity weight for death is taken into account[6].The person died because of severe watery diarrhoea was a male at the age of 57. According to National post (Umarov, 2015), the average life expectancy for 2016 in Uzbekistan for female and male are 76 as opposed to 73.5. The calculation of burden of disease per case in DALYs is shown in the following Table 8:

Table 8. Calculation of burden of disease per case in DALYs

Outcomes	Severity	Duration	Burden of disease per case in DALYs
Watery diarrhoea	0.067	7 days (0.02 years)	0.0013 (YLD)
Mortality	1	16.5 years	16.5 (YLL)

The formula of DALYs is Number of cases times Severity weight times Duration. The number of symptomatic cases of Cryptosporidiosis in the city of Tashkent was assumed as 6609. Since more likely that those with the low immune system are more tend to die from watery diarrhoea, the mean mortality risk for Cryptosporidiosis will be based on immunocompetent population. That number is taken from the Milwaukee outbreak experience and estimated as 1/0.0001 cases (Vijgen et al., 2007). DALYs data per 1000 symptomatic cases of Cryptosporidiosis is calculated and gives the result of 1.5 in the following Table 9:

Table 9. DALYs data per 1000 symptomatic cases of cryptosporidiosis

Outcomes	DALY per 1000 symptomatic cases of cryptosporidiosis
Watery diarrhoea	1000 x 0.067 x 0.02 = 1.34
Mortality	1000 x 10^{-5} x 16.5 = 0.165
Total	1.34+0.165 =1.5

Since, according to GloWPa model the average concentration level of *Cryptosporidium* equals to 3.9 $\log_{10}$ per litre, thus annual risk of infection equals to 1 ($person^{-1}yr^{-1}$), and everyone in the city gets infected by Cryptosporidiosis, DALYs for the whole population of the city of Tashkent is calculated. DALY per the city of Tashkent is 3300. That means if drinking water in the city of Tashkent will be effectively treated, it will save 3300 DALYs per year. Economic value per DALY can be calculated based on the most real scenario developed in section 5.3.

[6] Data on diarrhoea for 2015. Sanitary and Epidemiological Station of the Republic of Uzbekistan, not available online.

3.3.3. Cost benefit analysis

To analyze cost and benefits, necessary variables are defined. Since UV water treatment method is the most effective among Chlorination and Ozonation, the focus falls on cost and benefits of the use of UV. The average price of UV installation equals to 1500€ per house [7] and nearly 855 million € are necessary to treat all households in the city of Tashkent with the amount of 552891 families. However, filters must be maintained every 12 months and it costs in average 30€[8] If the population of the city if Tashkent is 2,309,300, then an approximate number of people per family is 4.2. To estimate pay off period for investment on installation and use of UV, four scenarios are developed (Table 10):

Scenario A – a person gets full medical treatment that includes 7 bed-days at the hospital, thus he/she skips 7 working days. Also, a person consumes dietary food and takes full medical supplies.

Scenario B – a person goes to the hospital for 1 day to make a clinical diagnosis, but he/she continues to work. Also, a person consumes dietary food and takes full medical supplies.

Scenario C – a person does not want to go to the hospital and prefer to receive treatment on his/her own at home (or if a person goes to the hospital, but medical treatment for infectious diseases in Uzbekistan are for free), but still a person consumes dietary food and takes full medical supplies.

Scenario D – a person does not want go to the hospital and prefer to receive treatment on his/her own, without skipping the work, a person consumes dietary food and takes full medical supplies.

Table 10. Amount spent on per course of a medical treatment (€) according to scenarios

	Scenario A	Scenario B	Scenario C	Scenario D
Average number of bed-days of a single person (days)	7	1	7	0
Sum of average number of bed-days (UZS) in hospital	368523	52646	0	0
Sum of diagnostic testing (UZS)	468882	468882	0	0
Dietary food per course of a medical treatment (UZS)	65800	65800	65800	65800
Costs for the medical supplies (UZS)	221375	221375	221375	221375
Cost of skipping working days	34944	4992	34944	0
Total amount spent on per course of a medical treatment (€)	**341**	**239**	**95**	**84**

[7] [8] GM Autoflow (2016) Cintropur UV 10000 Water Treatment, Last modified December 9, 2016, Retrieved from http://www.gmautoflow.co.uk/cintropur-uv-10000-water-filter-c2x14417399

In the case of any scenario, a person assumed to take full medical supplies and dietary food. Scenario D can be considered as a more real outcome since in Tashkent, people not often complain to hospitals about watery diarrhoea and do not skip working days. If the whole population of Tashkent is 2,309,300 people and the annual risk of infection in conditions of business is 1 $(person^{-1}yr^{-1})$ (which means every person get infected by *Cryptosporidium* at least once per year in condition on people drink 2 litres of tap water per day), then whole population of Tashkent spends at least 193981200 € per year on medical treatment (based on Scenario D). Minimum wage in Uzbekistan is 149,775 UZS, which is approximately 44 €. Then 1 working day is 1.4 € and amount of salary missed is 10 € (based on minimum wage). Thus, economic value per DALY is calculated by the following way 194814307.2 / 3300 = 59035 €. That means each adverted DALY gives 59035 € economic benefit.

With the reference to Dore et al,. (2008), estimated cost function for UV, Chlorination, and Ozone are given for 2008, and in this study, it is estimated it for 2016. As prices were given in US dollars, that were converted to €. Interestingly, costs per 100m3 plant with the application of UV are approximately 63 cents cheaper per m3 than that for Chlorination (to Dore et al,. (2008) . The following Figure 11 shows a correlation between prices and effectiveness for each considered type of water treatment based on Dore, Khaleghi, Singh, & Achari (2008):

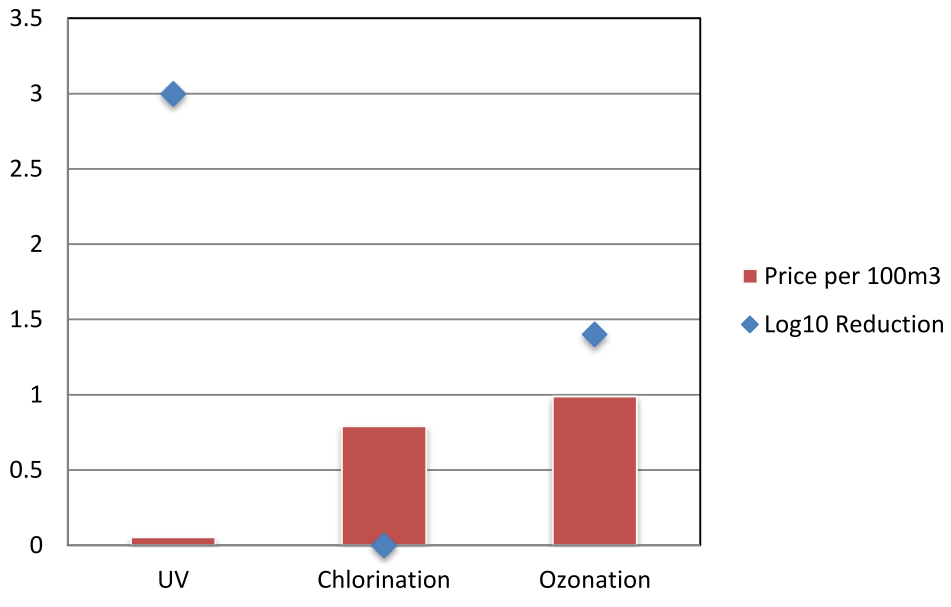

Figure 11. Correlation between prices and effectiveness for each considered type of water treatment (adapted from Dore, Khaleghi, Singh, & Achari, 2008)

If it is assumed that person drinks 2 litres per day and SUE “Suvsoz” provides with water the area of 340 km3, then the whole amount of water consumed per year would be 1,685,789 m3. To calculate UV, the equation for the calculation of average cost function given by to Dore et al,. (2008) is used. The average cost function for UV Dose 40 mJ/cm2 is:

$$y = 0.4228x^{-0.4821}$$

The average cost function for UV Dose 40 mJ/cm2 is equal to approximately 16.5 €. Thus annual UV water treatment per year costs approximately 22347 € per m3. As it is mentioned above, the amount of money should be invested by SUE "Suvsoz" is approximately 855 million €. However, a cash inflow can be different according to scenarios given in Table 11 (all the prices below are given in €):

Table 11. Payback period for the installation and use of UV water treatment method in the city of Tashkent

	Scenario A	**Scenario B**	**Scenario C**	**Scenario D**
Economic benefit per person	341	239	95	84
Economic benefit for the city of Tashkent	786600034	551995918	218519682	194814307
Cost of annual filter maintenance	256430855			
UV costs per year	22347			
Cash inflow (€)	530146832	551995918	218519682	194814307
Pay-off period (years)	2	2	3	4

The inflation rate in Uzbekistan equivalents to 0.07. As a result, the calculation according to Scenario D with the most real outcome approximately 4 years is necessary to payback initial investments by SUE "Suvsoz" to provide households with tap water treated by UV.

Discussion and Conclusion

4.1. Discussion

In this section, methods used and results of the research are discussed one by one according to the research questions. First, a short summary of the problem statement is provided, followed by results on concentration level and exposure to the citizens of the city of Tashkent. Next, in the section dose-response analysis is discussed, subsequently, cost-benefit calculation explanation is given with small general discussion on the overall working process as a closing part. World National Consultation (2015) states that in Uzbekistan the hydrological data is in open access to its basic customers. However, in reality, it was not easily possible to get data on water, as it was considered confidential information.

4.1.1. Concentration of *Cryptosporidium*

This study is focused on the following objectives: (i) to propose solutions to improve the microbiological drinking water quality in the city of Tashkent; and (ii) to assess costs and benefits of the most applicable water treatment method. In the ideal situation, local citizens are able to drink two litres or more of potable water without a fear of becoming ill. Therefore two litres is set to be the daily ingestion of water for the population. To choose the most effective water treatment method, first, the actual concentration of *Cryptosporidium* in the surface water for drinking in the city of Tashkent is identified via GloWPa model. The concentration is considered to be $3.9 \log_{10}$ per litre, that makes clear that water quality in the city is grossly polluted. The results of the model are uncertain. Firstly, because the current results of GloWPa model on concentration are preliminary, as the runoff of livestock manure part runoff and the die-off in the water will be changed in the model. Also, GloWPa is a global scale model, and it is simply used the value from the grid that covers the city of Tashkent, which is most likely incorrect. However, the obtained value of the GloWPa model used as an indication to start my analysis and does not influence the conclusions.

Furthermore, GloWPa estimates higher *Cryptosporidium* concentrations in winter compared to summer. While concentration of the oocysts of *Cryptosporidium* is comparably low in summer, the number of complaints on watery diarrhoea to hospitals is much higher. That could be a reason to assume the model is not valid enough, but since the cause of watery diarrhoea is not defined, the reason for the disease does not have to be Cryptosporidiosis. During the summer a lot of people get food poisoning as a consequence of very high temperature and improper storage of products, for instance when cooking outside. And also, in reality, people do not drink water directly from the tap, but they go swimming or wash vegetables, fruits or dishes with contaminated water. Low summer concentrations can be realistic, as natural UV radiation can be a reason of low concentration of *Cryptosporidium* since it is able to significantly reduce *Cryptosporidium* parvum (Connelly et al., 2007). These factors are important, but they are not that important to take into account to drawing the conclusions.

4.1.2. Dose-response model

Dose-responses analysis showed daily risk, the annual risk of citizens of the city of Tashkent being infected by *Cryptosporidium*. First, it was important to choose a model to calculate dose-response relationship. Some literature used exponential model, some Beta-Poisson. As a result, the latter was chosen with already given parameters of α = 0.115, β = 0.176 by Smeets, van Dijk, Stanfield, Rietveld, & Medema (2007), because mainly the basis for the whole research was a work by Medema (2009, 2010). The calculation of dose-response analysis was done on R studio with mcstoc R package. The yearly risk of infection was 1 ($person^{-1}yr^{-1}$) was calculated, which means that every person gets infected by *Cryptosporidium* at least once per year. Meanwhile, acceptable annual risk of infection is 0.0001 oocyst of *Cryptosporidium*. To reduce the concentration three methods of water treatment namely Chlorination, Ozonation, UV were reviewed. According to literature, Chlorination was futile, since it gives 0 reduction of *Cryptosporidium,* while that for Ozonation and UV were 1.5 $\log_{10}$ and 3.0 $\log_{10}$ respecitvely. To check the effectiveness in this particular concentration level in the city of Tashkent, annual risk reduction was simulated in R. While writing the code, the dose number was reduced in accordance with chosen water treatment methods. It demonstrated that both Ozonation and UV give annual risk of 1 ($person^{-1}yr^{-1}$). That means the chance of being infected was very high and drinking water directly from the tap even in the condition of different water treatment method would remain as unsafe. However, as the results of GloWPa model was uncertain, the concentration of *Cryptosporidium* in the city of Tashkent likely lower, in that case UV water treatment would be effective enough to reduce annual risk of infection to acceptable level. After the same dose-response analysis has been done, but since water was admitted as grossly polluted, it was assumed that there are 100 oocyst of *Cryptosporidium* per litre. And that calculation gives the results that then application of UV water treatment still not effective enough. But the expenses on installation and use are comparably lower than those for Chlorination and Ozonation. Even though UV was not effective enough that high concentration level, but since according to literature reviewed, dose-response analysis showed that UV has the highest reduction compared to Chlorination and Ozonation Therefore, further research was done based on UV water treatment application only.

4.1.3. Costs and Benefits

First of all, the DALY unit was calculated to see effects of health hazard by *Cryptosporidium*. The result showed 16.5 years of life lost due to mortality caused by water diarrhoea and 0.0013 years lived with disability. The total DALYs for the city of Tashkent was equal to 3300 with 59035 € per DALY averted. Turning to the calculation of medical treatment cost, treatment of watery diarrhoea lasts in average 7 bed-days in the hospitals in Tashkent. In general, it costs 330 € for the whole medical treatment period, that includes all the services provided, including medicines. In fact, medical treatment for infectious diseases in Uzbekistan is for free for the citizens. However, medicines must be covered by the patient himself/herself, that is approximately 65 €. Also, it is necessary to consider that the minimum wage in Uzbekistan per month is 44 € and local citizens do not have health insurance. That gives a logical image of that even medical treatment for infectious diseases is for free, but medicines that must be taken costs 28.6 per cent more than salary itself. These costs cannot be carried by a person with the lowest salary to get a complete proper medical help. At the same time, if a single person skips 7 working days, because of suffering by watery diarrhoea the hospital, this period would cost him/ her 10 € per treatment period. However, if in total it costs 330 € per person per treatment, and in average there are 4.2 people per family in the city of Tashkent, then in an average whole population of the city would spend 762 million € per year on medical treatment in case of annual risk of 1. However, to make the calculations more valid, four scenarios on medical treatment were developed. According to Scenario D, a person skips bed days at the hospital and diagnostic testing for infectious diseases, gets treatment independently, consumes dietary food, takes full medical supplies but continues to go to work is considered as the most valid outcome for the case of the city of Tashkent. In that case, a person spends 84 €o per medical treatment.

Turning to the calculation of costs and benefits on UV water treatment installation, UV was found as the cheapest, and as mentioned the most effective. And if SUE “Suvsoz” would invest 855 million € with the average inflation rate in Uzbekistan of 0.07, four years would be necessary to payback initial investments. Here, then the government would think not the loss of 855 to update and install new water treatment, but about the social benefit, that would have a positive impact on health, wellness, life quality, financial conditions of the local citizens.

4.1.4. Assumptions and Uncertainties

The overall working process was quite hard due to unavailability of data. The whole research was based on idea of making possible to drink two litres of water per person per day. As it is mentioned above, data on concentration level generated by GloWPa was admitted as very uncertain. Therefore, every further calculation must be perceived as an assumption, including dose-response analysis. It is necessary to notice that accounting costs on medical treatment, DALY are considered as reliable, all the numbers are valid. But DALY calculation also has uncertainties, since currently, people boil the water, and cryptosporidiosis is not determined in Uzbekistan, also there is no evidence that one case of death from watery diarrhoea was because of cryptosporidiosis. However, DALY is still reliable, because those who get infected by *Cryptosporidium* have 7 disability days on average. Also, the average life expectancy for 2016 in Uzbekistan is given correctly. Thus, these numbers would remain the same in any case.

The effectivity of UV, that it can fully clean water from *Cryptosporidium* in the case of the city of Tashkent is also a hypothetical situation since local citizens there, in reality, do not drink water directly from the tap, especially in the amount of two litres. However, general information of the effectivity of UV is not doubted in this research. Also, variation in the exchange rate of currencies must be taken into account before the results of the research will be put into action. Since there are lots of uncertainties in this research, it can be suggested that citizens of the city of Tashkent must continue to consume only boiled or bottled water, since the research on the immune response is also unclear according to the literature reviewed. However, despite the uncertainties in the exact numbers, application of UV water treatment technologies would payback relatively quickly.

4.2. Conclusion

4.2.1. Concentrations of Cryptosporidium

According to GloWPa model, the concentrations of *Cryptosporidium* in the surface water for drinking is 3.9 $\log_{10}$ per litre, that makes clear that drinking water quality in the city is grossly polluted. It is assumed that in the city of Tashkent each person consumes two litres of water directly from the tap per day. However, currently, local citizens in the city of Tashkent drink only boiled or bottled water. But this research is based on the ideal situation when people are able to drink 2 litres of water directly from the tap. In reality, people do not drink water directly from the tap, but they go swimming or wash vegetables, fruits or dishes with contaminated water. However, these factors are out of the frame of this research. The yearly risk of infection by 1 $(person^{-1}yr^{-1})$ was calculated, which means that every person gets infected by *Cryptosporidium* at least once per year. Meanwhile, acceptable annual risk of infection is 0.0001 oocyst of *Cryptosporidium*. There are several *Cryptosporidium* inactivation methods exists. The focus of this research falls on Chlorination, Ozonation and UV water treatment methods. Disinfection from *Cryptosporidium* by Chlorine, chloramines, Chlorine dioxide gives poor results. However, application of both Ozonation and UV water treatment methods considered are more effective. Meanwhile, this research is done based on the concentration level retrieved from GlowPa model, thus for both application of Ozonation and UV gave result on annual risk equal to 1 $(person^{-1}yr^{-1})$. That means even though Ozonation has a 1.5 log10 reduction and UV a 3.0 log10 reduction this is not effective enough to reduce that high concentration of oocyst of *Cryptosporidium* in drinking water in the city of Tashkent. Consequently, the population of Tashkent should keep boiling tap water. Presumably, another water treatment, or a combination of treatment options should be applied to achieve acceptable annual risk of infection. However, UV water treatment method gives comparably better effect, also it costs less than currently used Chlorination method or perspective Ozonation.

4.2.2. Costs and Benefits

First of DALYs for the whole population of the city of Tashkent was calculated and gave the result of 3300 DALYs. That means if drinking water in the city of Tashkent will be effectively treated, it would approximately save 3300 DALYs per year, while each DALY costs 59035 €. The annual amount of money spent on per course of a medical treatment for watery diarrhoea per person is 341 € on average. The amount of money should be invested by SUE "Suvsoz" is approximately 855 million. Four scenarios were developed where the number of days skipped from work, the medical testing and treatment were varied. The scenario with the most real outcome is when a person having watery diarrhoea presumably by being infected by *Cryptosporidium* does not want go to the hospital (in any case medical treatment from infectious diseases in the city of Tashkent is for free) and/or prefer to receive treatment on his/her own without skipping the work, and still consumes dietary food and takes full medical supplies. The calculation of payback period was based on the mentioned scenario, also on UV dose cost and cost of annual filter maintenance. As a result, 4 years are necessary to payback initial investments in case of the scenario of the most likely outcome. If the complete switch to UV is decided to be too expensive to be used in coming future, it is suggested continue boiling the water. Further study to apply this approach to better reduce the risks include more precise measurements pf Cryptosporidium concentrations in the City of Tashkent and better determining the efficiency of drinking water treatment approaches. However, despite the hypothetical nature of this thesis, my approaches to assess risk and costs is sound. This thesis, its structure can be surely used as a guidance for further research.

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Appendices

Appendix A.

Order number 526 of Ministry of Health of the Republic of Uzbekistan Order on “Approval of the procedure of formation of tariffs for paid services and the list of paid medical services rendered to the population of the Republic of Uzbekistan Ministry of Health medical institutions" (In Russian).

O`ZBEKISTON RESPUBLIKASI
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07.01.2008 № 15-7/361

№га

Начальникам отделов реформирования,
приватизации и платных услуг
Минздрава РКК, ГУЗ г.Ташкента и
УЗ областей, руководителям
республиканских ЛПУ

Разъяснения

к приказу Министерства здравоохранения Республики Узбекистан

от 26 ноября 2007 года №526

В связи с поступающими вопросами по приказу Министерства здравоохранения от 26 декабря 2007 года №526 разъясняем следующее:

1-вопрос: Можно ли оказывать на платной основе в первичном звене здравоохранения платные услуги по перечню, утвержденному приложением №2 данного приказа?

Ответ: В соответствии с приказом Министерства здравоохранения от 17 мая 2006 года №222 в учреждениях первичного звена здравоохранения платные услуги оказываются согласно приложению №2 приказа № 222, т.е. учреждениям, предприятиям и организациям по перечислению, нерезидентам, а также медицинские осмотры декретированного контингента и шоферских комиссий.

2-вопрос: Почему в состав калькуляции внесены отдельной строкой налоги?

Ответ: В соответствии с Указом Президента Республики Узбекистан от 19 сентября 2007 года № УП-3923, лечебно-профилактические учреждения, оказывающие населению платные медицинские услуги (кроме стоматологических и косметологических) освобождены сроком до 1 января 2013 года от уплаты всех налогов и других обязательных платежей, с целевым направлением высвобождаемых средств на оснащение медицинского учреждения современным медицинским оборудованием. Исходя из вышеизложенного, лечебно-профилактические учреждения должны вести отдельный учёт сумм, высвобождаемых в результате освобождения от уплаты налогов.

3-вопрос: Почему в пункте 10 указано, что в состав накладных расходов не включаются расходы, покрываемые из бюджета?

Ответ: В лечебно-профилактических учреждения, подлежащих поэтапному переводу на платные медицинские услуги, в состав накладных расходов не включаются расходы отделений, оказывающие гарантированную государством бесплатные медицинские услуги (детские, родовспомогательные подразделения и подразделения для лечения социально-значимых заболеваний).

4-вопрос: Какие амортизационные расходы можно включать в стоимость услуг?

Ответ: Если оборудование приобретено за счет внебюджетных средств и числится на балансе хозрасчетного лечебно-профилактического учреждения или отделения, то амортизационные расходы включаются в стоимость услуг, при том условии, что поступившие средства от амортизации оборудования отчисляются в амортизационный фонд.

5-вопрос: Как можно рассчитать надбавки за сервисные услуги?

Ответ: За дополнительные сервисные (комфортные) условия, предоставляемые по желанию пациента, надбавки устанавливаются в процентном отношении **к сумме койко-дня без отчислений** (графа 6):

а) одноместная палата

люкс - 25% (k 0,25),

полулюкс – 15% (k 0,15),

б) двухместная палата

люкс - 15% (k 0,15),

полулюкс - 10% (k 0,1),

в) телефон - 10% (k 0,1),

г) телевизор - 10% (k 0,1),

д) холодильник – 10% (k 0,1),

е) отдельный санузел - 10% (k ,1),

ж) кондиционер - 10% (k 0,1),

з) предоставление удобного для пациента времени получения медицинской услуги (для амбулаторно-поликлинических учреждений) - 25% (k 0,25).

6-вопрос: Почему стоимость питания и медикаментов не включена в стоимость калькуляции?

Ответ: Стоимость питания больных не входит в стоимость койко-дня и оплачивается исходя из норм продуктов питания, определенных приказом Министерства здравоохранения №122 от 19.03.1993 г., действующих цен и меню-раскладок. Стоимость расхода медикаментов не входит в стоимость койко-дня и оплачивается по фактическим затратам.

7-вопрос: Как рассчитывается в приложении №2 «Калькуляция стоимости медицинских услуг»?

Ответ:

1. Порядковый номер услуги;

2. Общее медицинское наименование услуг;

3. Должность исполнителей услуг (врач, медсестра, санитарка и т.д.);

4. Оклад для каждой должности проставляется с учетом надбавок, доплат, отпускных и др. средств, оформленных трудовым договором;

5. По действующему законодательству продолжительность рабочего времени (в часах) – 6.0, 5.5, 5.0 часа (без перерыва на обед);

6. Время в минутах на каждое действия работников, участвующих в процессе оказания медицинской помощи, вписанное в графу 3;

7. Стоимость рабочего времени:

гр.4 х 12 : 11 = среднемесячная заработная плата : 25,4 (среднемесячный рабочий день) = заработная плата в день : гр.5 = заработная плата в час: 60 минут = стоимость 1 минуты х гр.6;

8. Начисление на соц.страх 25%: гр.8 = гр.7 х 25 : 100;

9. Накладные расходы не могут быть прямо отнесены на стоимость услуг и переносятся на их стоимость следующим способом:

$$HP = \frac{ФЗП_{АУПХП} + (IV\ гр - (М + П + КР + МО))}{ФЗП_{ОП}} \times 100\%$$

где, НР – накладные расходы;

ФЗП АУП и ХП (с начислением на соц.страх) - фонд зарплаты административно-управленческого и хозяйственного персонала с начислением на соц.страх;

IV гр.- IV группа расходов (другие расходы);

М - расходы на медикаменты;

П - расходы на питание;

КР - расходы на капитальный ремонт;

МО - стоимость медицинского оборудования;

ФЗП ОП – фонд заработной платы основного медицинского персонала;

10. Амортизационные расходы;

11. Всего: гр.7 + гр.8 + гр.9 + гр.10;

12. Рентабельность до 15 процентов: гр.11 х 15 : 100;

13. Итого затрат: гр.11 + гр.12;

14. Надбавка за сервисные услуги: гр.13 х % сервисных услуг;

15. Всего затрат: гр.13 + гр.14

16. На содержание Центра (отдела) приватизации и организации платных услуг, согласно приказу Минздрава РУз от 20 октября 2003 года №452; гр.15 х 2 : 100;

17. Всего затрат: гр.15 + гр.16;

18. Расходные материалы;

19. Расходы на лекарственные средства.

20. Всего затрат: гр.17 + гр.18 + гр.19;

21. Налог на прибыль: гр.12 + гр.14 х 9% : 100;

22. Налог на инфраструктуру: (гр.13-гр.11-гр.21) х 8% : 100;

23. Всего: гр.21 + гр.22;

24. Всего расходов: гр.20 + гр.23;

25. Отчисления в дорожный фонд: гр.24 х 1,5% : 100;

26. Отчисления в пенсионный фонд: гр.24 х 1,5% : 100;

27. Отчисления в Фонд школьного образования: гр. 24 х 0,5% : 100;

28. Итого стоимость услуги: гр.24 + гр.25 + гр.26 + гр.27;

8. Вопрос: Как рассчитывается в приложении №2 «Расчёт 1 койко-дня»?

Ответ:

1. Наименование отделения;

2.1. Заработная плата медицинского персонала;

2.2. Начисление на социальное страхования: гр.2.1 х 25 : 100;

2.3. Накладные расходы: (гр.2.1 + гр.2.2) х % накладных расходов;

2. Всего: гр.2.1 + гр. 2.2 + гр.2.3;

3. Рентабельность до 15 процентов: гр.2 х 15 : 100;

4. Итого затрат: гр.2 + гр.3;

5. Объем работы, план койко-дней за текущий год;

6. Всего: гр.4 : гр.5;

7. Надбавка за сервисные услуги: гр.6 х % сервисных услуг;

8. Всего: гр.6 + гр.7;

9. На содержание Центра (отдела) приватизации и организации платных услуг: гр.8 х 2 : 100;

10. Стоимость 1 койко-дня без налогов и платежей: гр.8 + гр.9;

11.1. Налог на прибыль: (гр.3: гр.5+ гр.7) х 9 : 100;

11.2. Налог на инфраструктуру: (гр.3 : гр.5 – гр.11.1) х 8 : 100;

11. Всего: гр.11.1 + гр.11.2;

12. Всего расходов: гр.10 + гр.11;

13. Отчисления в дорожный фонд: гр.12 х 1,5 : 100;

14. Отчисления в пенсионный фонд: гр.12 х 1,5 : 100;

15. Отчисления в Фонд школьного образования: гр.12 х 0,5 : 100;

16. Стоимость 1 койко-дня: гр.12 + гр.13 + гр.14 + гр. 15.

9-вопрос: Что такое материальные затраты (медикаменты и изделия медицинского назначения)?

Ответ: К материальным затратам в части медикаментов и изделий медицинского назначения включаются так называемые расходные материалы: реактивы, перевязочные средства, одноразовые шприцы, система для переливания крови, диагностические средства, иглы, дезинфицирующие средства и инструментарии, сосудистые и иные протезы, шунты, вживляемые в организм больного приспособления шовные материалы и другие, которые непосредственно используются в процессе осуществления услуги или технологически связаны с осуществлением услуги, вследствие чего включаются в калькуляцию стоимости услуги.

Примечание: при изменении процента начисления на соцстрах, а также ставок обязательных налогов вносятся соответствующие изменения в калькуляции.

Директор Центра приватизации

и организации и платных услуг **А.А.Агзамов**