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The impact of the floral industry on water pollution in Kenya

Bachelor Thesis

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Declaration

I declare that I have written my bachelor thesis on a topic "The impact of floral industry on water pollution in Kenya" all by myself with the help of literature listed in References.

Prague, April 7th 2016 . . . .

Adam Kraus

Acknowledgement

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Abstrakt

Keňa patří mezi země, které trpí nedostatkem čisté vody. Velká část obyvatel má ztížený nebo dokonce téměř žádný přístup ke zdrojům čisté vody. Znečištění keňských vodních zdrojů způsobuje poměrně rozvinutý průmysl a zemědělství, které je zdrojem obživy pro většinu místních obyvatel. Obě tato odvětví samozřejmě využívají vodu z jezer a řek, což vede k její kontaminaci a také k jejímu úbytku. Záporný vliv na kvalitu zdejší vody má i špatný nebo vůbec žádný kanalizační systém ve městech a vesnicích. Existují různé způsoby, jak z přírodních zdrojů získat vodu čistou, pitnou nebo alespoň užitkovou. Tato bakalářská práce je zaměřena na květinový průmysl a květinové farmy, kterých jsou v Keni desítky a jejich dopad na znečištění vodních zdrojů a životního prostředí. Cílem práce je navržení technologie čištění vody z těchto farem. Největší a nejznámější z nich se nacházejí v okolí jezera Naivasha, další květinové farmy je možné najít v blízkosti hlavního města Nairobi, u města a stejnojmenného jezera Nakuru, poblíž města Limuru či v provincii Western. Keňa je jedním z dominantních producentů řezaných růží, gerber, chryzantém a karafiátů na světě. Pěstování květin se ale neobejde bez používání škodlivých a vysoce jedovatých chemikálií, které ohrožují zdraví lidí a znečišťují vodu v dosahu farem. Z dalších negativních faktorů je skutečnost, že květinové farmy produkují velké množství odpadu a kalu. Odpadní vody se tu běžně nečistí, odpad způsobuje kontaminaci půdy, řek, jezer i podzemních vod.

Klíčová slova: Keňa, květinový průmysl, květinové farmy, znečištění vody, technologie pro čištění vody, nedostatek vody, pitná voda

Abstract

Kenya belongs to countries which suffer from a lack of clean water. A large number of population have difficult or even no access to clean water sources. The pollution of Kenyan water sources is caused by relatively developed industry and agriculture which is a significant source of livelihood for a vast majority of the local population. Of course, the consumption of water from lakes and rivers by both these spheres results in its contamination and decrease. The quality of water is also negatively affected by poor or even missing sewage system in local cities and villages. There are several ways to get clean water, drinking water or at least utility water from natural resources. This bachelor thesis is focused on the floral industry and floral farms, many of them to be found in Kenya and their impact on pollution of environment. The aim of this essay is to suggest the technology method for water purification from these farms. The largest and most known floral farms are situated in the vicinity of Naivasha Lake, several others are located near Kenya's capital Nairobi and Nakuru Lake and town and also near the town Limuru or Western province. Kenya is an enormous grower of cut roses, gerberas, chrysanthemum and gillyflowers. The flower planting cannot however work without use of harmful and poisonous chemicals, which endanger the human health and influence the water around the farms. The farms also generate a great deal of fallout and sediment. Wastewater is not usually cleaned here, therefore the sewage triggers the contamination of soil, rivers, lakes and underground water.

Keywords: Kenya, floral industry, floral farms, water pollution, technology for water purification, lack of water, drinkable water

Content

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List of Abbreviations

CIA	Central Intelligence Agency
CO_2	Carbon dioxide
CPU	Central purification unit
CWs	Constructed wetlands
FAO	Food and Agriculture Organization
GBH	Gravel bed hydroponic
GDP	Gross domestic product
JMP	Joint Monitoring Programme
MF	Microfiltration
MOCP	*Moringa olifera* Coagulant Protein
NF	Nanofiltration
PSFF	Pressure single-chamber filling filter
RO	Reverse osmosis
SPAs	Service Provision Agreements
UF	Ultrafiltration
USD	United States dollar
WASREB	Water Services Regulatory Board
WSBs	Water Service Boards
WSPs	Water Service Providers

1 Introduction

On Earth, water belongs among the most basic natural resources, it is also one of the most important elements of nature and environment. Water significantly interferes with a person's life, both excess and its lack. On Earth, there is not a lack of water in general, but there is a shortage of fresh water, clean and potable water. More than 70 % of the world's surface is covered by water, but only 3 % represent the fresh water sources (Figure 1). Water supplies on Earth are distributed very unevenly.

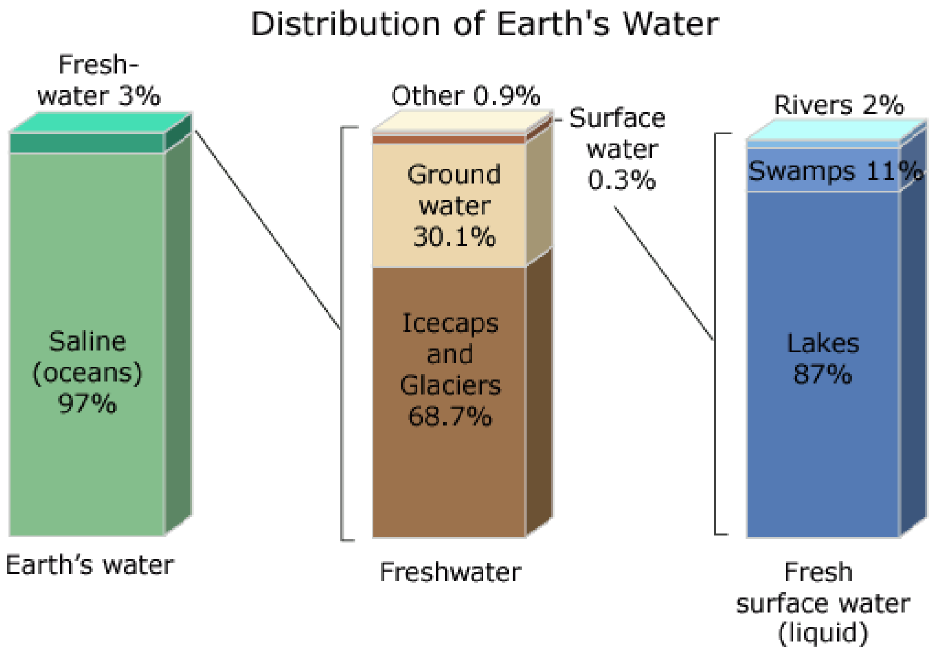

Figure 1: Distribution of Earth's Water, 1996 (Gleick PH, 1996).

The main causes of water shortage on Earth include population growth, climate impacts, waste of water in developed countries and pollution of water resources by man (pesticides, fertilizers, sewage, industrial waste water, etc.). And just water contamination is one of the biggest problems of the contemporary world and greatly restricts access of the population to drinking water. The worst situation is in sub-Saharan Africa, Central and Southeast Asia, India, China and in the southwest of the United States. This problem can be solved in several ways:

- Limitation of water wastage in developed countries
- The funding of clean water sources
- Financing of hydrogeological investigations

This thesis focuses on how to preserve drinking water resources and improve its quality through various technologies. It focuses on East Africa region, in particular on the issue with drinking water in Kenya. Kenya has enough natural water sources, but many of them are salty and their water is usable, and are moreover prone to drying out as a result of long periods of drought, which affects the equatorial region. One of the main polluters of water resources in Kenya is the flower industry, which is in the last twenty years growing mainly in the Rift Valley, around the capital Nairobi, town Naivasha, Nakuru, Limuru and Kintengela. Near the flower farms, such as Karuturi Farm, Isinya Roses and several others grew new villages, however, without sanitation and sewage system. All the wastage from flower farms flows directly into lakes, rivers and causes groundwater pollution. The most polluted is Lake Naivasha, the situation is also critical around the Lake Nakuru, which is located in the national park of the same name.

Growing flowers consumes a huge amount of water, the flowers are grown in beds and in greenhouses. Farms use a range of agricultural chemicals that threaten human health and contaminate the water within their reach, generate waste containing pesticides, herbicides and insecticides. Wastewater is not routinely cleaned. This problem is the main topic of this thesis, which will explore the possibilities, how to clean the wastewater in a timely manner and prevent pollution of the surrounding water resources and the environment.

2 The aim of the thesis

The main objective of this work is to suggest wastewater treatment technologies from flower farms which would lead to as little pollution as possible of natural water resources, which are the source of livelihood not only for local fauna and flora, but are above all indispensable for humans. The appropriate wastewater treatment technologies are designed to be most relevant for the local environmental conditions. The goal is to reach a better quality of wastewater and prevent runoff of contaminated water into lakes and rivers within easy reach of flower farms. Part of this work will also propose saving water in periods of drought.

This thesis presents the most comprehensive overview of all sources of water pollution produced by the floral industry. For this purpose, a variety of statistics and scientific articles are used, which should contribute to detect the most important sources of water pollution and help design the most appropriate method of cleaning and simultaneously suggest preventive solutions that would avoid the water pollution in natural resources. It is not only about the treatment of wastewater from flower farms, the attention must also be paid to the drainage system of nearby villages and towns, which are closely related to the mentioned issue.

3 The used methods

A search-compilation method of data collection and subsequent analysis was used for the Bachelor thesis. For the general characteristics were used mainly printed resources, for other chapters, mostly electronic resources.

An important source of information was the website of the CIA and site of FAO. There were also used information from professional journals, scientific articles, and other expert materials including numerous thesis and studies selected from the Web of Science. However, one of the main sources of information was a study of The Impact of the Flower Industry on Kenya's Sustainable Development, written by Bruno Leipold and Francesca Morgante.

The Bachelor's thesis is complemented with maps, pictures, photographs and charts for better comprehension of the text. The work uses footnotes, which help to explain some facts and specific terms and consequently their better understanding.

4 Literature Review

4.1 Background of the Republic of Kenya

4.1.1 Basic information

Country is situated in Eastern Africa and has borders with 5 countries (in the west with Uganda, in the south with United Republic of Tanzania, in the north with Ethiopia and South Sudan and in the east and north-east it with Somalia). The population of Kenya is 44,354,000 (2013) and the area is 582,646 km^2 (The Commonwealth, 2016). These data are slightly different, according to FAO (Figure 2). Religion in Kenya is mostly represented by Christianity, which reaches 82.5 %. Other religions do not reach numbers high like that. Only Islam with its 11.1 % is worth mentioning (CIA, 2016).

Capital and simultaneously the largest city is Nairobi, with population of 3.25 million inhabitants in 2010. Another significant city is Mombasa, which is an important transport centre because of its strategic position and the second largest city in Kenya. Among other bigger and known cities belong Nakuru, Eldoret, Kisumu, Ruiru or Thika (The Commonwealth, 2016).

The Republic of Kenya (which is the official name of Kenya) is a presidential representative democratic republic. Since 9th April in 2013 the president of Kenya is Uhuru Kenyatta. There are two official languages, English and Kiswahili, but there are also numerous indigenous languages (CIA, 2016).

4.1.2 Geography

Kenya lies between latitudes 5°N and 5°S, and longitudes 34° and 42°E across the equator in Eastern Africa, on the coast of the Indian Ocean. Coastline is 536 km long so thanks to this, Kenya has a great access to the ocean. As mentioned before, Kenya adjoins with Tanzania, Uganda, South Sudan, Ethiopia and Somalia. The longest borderline Kenya has with Ethiopia (867km) followed by Uganda (814 km), Tanzania (775 km), Somalia (684 km) and the shortest is with South Sudan that has only 317 km (CIA, 2016).

A large part of Kenya's surface is represented by the Great Rift Valley where the highest mountain, Mt. Kenya (which reaches 5 199 metres above sea level), is located. Hallmark of Kenya is that it has huge diversity of landscapes, from deserts, e.g. the

Chalbi desert, to glaciated mountains (FAO, 2015). The land is arid in the north. In the southwest of the country is located fertile region around the Lake Victoria. The Great Rift Valley splits western highlands from those that rise from the lowland on the coast. The Kenyan Highlands represent one of the most successful agricultural areas in whole Africa (CIA, 2016).

Kenya's biodiversity is protected by numerous national parks, reserves and sanctuaries, which cover almost 47 000 km² of land (FAO, 2015).

4.1.3 Climate

Climate is influenced by equatorial location of Kenya. The regions on the coast have a tropical character, with typical monsoon winds. The lowlands are hot and mostly dry, the highlands are much cooler. The temperature ranges from freezing to 40 °C. However, the temperature is affected by geographical location (FAO, 2015). For example the capital city Nairobi, which lies 1,700 metres above sea level, has a mean temperature that ranges from 13 °C to 25 °C. However, the second biggest city Mombasa, which is located on the coast, has a mean temperature that ranges from 23 °C to 29 °C (The Commonwealth, 2016). The hottest part of the year is February and March and the coldest is in July, until middle August.

The annual long-term average precipitation is approximately 630 mm. The precipitation depends also on geographical factors. In the north of Kenya, the precipitation does not reach more than 200 mm, but on the Mount Kenya the precipitation can easily reach over 1 800 mm. The rainfall distribution is separated into two periods. The first period includes long rains from March to May and the second period includes short rains from October to December. However, more than 80 % of the land area is considered as arid or semi-arid, with an annual precipitation between 200-750 mm (FAO, 2015).

4.1.4 Soils

Kenya has a wide range of soils. This is resulting from the variation in geology, in relief and last but not least, in climate. Soil resources vary from sandy to clayey, shallow to very deep and low to high fertility. Sandy loam soils with high fertility, which originated in the basin of the Lake Victoria from lava deposits, can be found in the plateaus northerly and southerly of Winam Bay. The volcanic pile of Mount

Elgon produces also fertile volcanic soils. These soils are famous thanks to the production of tea and coffee. Fertile dark brown loams that got developed on younger volcanic deposits are typical for the Rift Valley and nearby highlands. The sandy soils are the most widespread soils in Kenya. These sandy soils are typical for semiarid regions between the coast and the Rift highlands. There are enormous areas covered by red desert soils, especially sandy loams, in the north of the Rift. Soils in Kenya are highly endangered by erosion because of the deficit of forest cover (Ingham et al., 2013).

4.1.5 Economy

Kenya has one of the most developed economies in the East Africa, therefore it is considered as a hub of economy and transport in this region. The real GDP in Kenya has registered an average growth by 5 % in the past several years (CIA, 2016). In 2013, the GDP was 44.1 billion USD (FAO, 2015). The agriculture is contributing to GDP with 30 %, industry with 20 % and services approximately with 51 % (the biggest incomes of Kenya are from tourism).

About 67 % of the total population is economically active and there is about 75 % of Kenya's population employed in agriculture (Konrádová, 2015). Agriculture accounts for 65 % of total country's exports and includes five major sub-sectors: industrial crops, food crops, horticulture, livestock and fisheries (FAO, 2015).

The unemployment reaches high numbers around 40 % (CIA, 2016). A large number of the Kenya's business is in private ownership with many investors from foreign countries. Economic growth and stability, generation of employment and maximization of foreign earnings are the major aims of this policy. The economy in Kenya is dominated by the external market, tourism and agricultural exports (Ingham et al., 2013).

4.1.5.1 Agriculture

The economy in Kenya is reliant on agriculture and it plays an important role. The majority of the population is employed in this sector. The key foreign-exchange earners are fresh flowers and tea. Other important cash crops are sisal, cotton and obviously fruits and vegetables. Also coffee still takes part in the Kenya's economy, but it started declining in importance and earnings in the 1990s. Corn and wheat are two major crops for domestic consumption. Sugarcane used to be export crop in the past, but nowadays it has to be imported. Livestock is raised especially for milk products that are produced mainly for domestic use. The lack of water, infrastructure, and arable land (less than 10 % of land can be used for agriculture) slows down the further expansion, noticeably despite the importance of agriculture on the economy of the country.

Kenya suffers from lack of forests, which are extremely important. A vast majority of the area of forest reserves is wooded bush, bamboo and grass. Forests play an irreplaceable role in soil conservation and water resources. Wood is also used as a fuel. There is a program for planting new trees which has been initiated to speed up growing of new forests in ecologically appropriate areas.

Growing trend can be seen in fish and marine branch, but it still has small impact on economy. Main amount from fishing represent freshwater fish mainly from Lakes Victoria and Rudolf (Ingham et al., 2013).

4.1.5.2 Industry and manufacturing

Kenya is the most industrially developed country in the African Great Lakes region, but industry and manufacturing still makes only around 20 % of the GDP. In 2015, the industrial production growth rate reached 6.1 % (CIA, 2016). Industrial activity is located around the three largest urban centres, Nairobi, Mombasa and Kisumu. Priority sectors in Kenya are those, which include food, textile industry, leather industry, petroleum industry (Kenya has an oil refinery that processes imported crude petroleum into petroleum products, mainly for the domestic market.), printing industry and paper. Not less important is also a cement production industry (Konrádová, 2015).

4.1.6 Political and socio-economic situation

Kenya is a presidential representative democratic republic and the president (Uhuru Kenyatta) represents two functions, head of state and head of government. Specific for Kenya is that it is a developing country. In last few years Kenya’s economic profits started to grow. The economic problems in the past were caused mainly by the fact that Kenya was a colony of Great Britain. Kenya became an independent country in 1964.

The first president of this country was Jomo Kenyatta, father of actual Kenya president Uhuru Kenyatta. Successor of Jomo Kenyatta was Daniel Arap Moi who was elected in 1979. Next twenty years Kenya suffered from economic crisis and political instability. Now, the president is previously mentioned Uhuru Kenyatta who was elected in 2013 (Konrádová, 2015).

Basic statistics and population

Physical areas:			
Area of the country	2012	58 037 000	ha
Agricultural land (permanent meadows and pasture + cultivated land)	2012	27 430 000	ha
• As % of the total area of the country	2012	47	%
• Permanent meadows and pasture	2012	21 300 000	ha
• Cultivated area (arable land + area under permanent crops)	2012	6 130 000	ha
- As % of the total area of the country	2011	11	%
- Arable land (temp. crops + temp. fallow + temp. meadows)	2012	5 600 000	ha
- Area under permanent crops	2012	530 000	ha
Population:			
Total population	2013	44 354 000	inhabitants
- Of which rural	2013	75	%
Population density	2013	76	inhabitants/km^2
Economy and development:			
Gross Domestic Product (GDP) (current US$)	2013	44 101	million US$/year
• Value added in agriculture (% of GDP)	2012	30	%
• GDP per capita	2013	994	US$/year
Human Development Index (highest = 1)	2013	0.535	-
Gender Inequality Index (equality = 0, inequality = 1)	2013	0.548	-
Access to improved drinking water sources:			
Total population	2012	62	%
Urban population	2012	82	%
Rural population	2012	55	%

Figure 2: Basic statistics and population (FAO, 2015).

4.2 *The Floral industry in Kenya*

4.2.1 Basic information

Kenya belongs to countries which export a large number of cut flowers. In particular, Kenya is the third biggest exporter in the world. Kenya's the most cultivated and also exported flowers are roses, carnations and summer flowers which are famous thanks to their long lasting effect. Cut flowers from Kenya represent approximately 35 % of all flower sales in the European Union. The majority of Kenya's cut flowers which are exported to Europe goes to Holland (66 %), Great Britain (17 %) and Germany (5 %). The rest (12 %) is divided among other European countries. Furthermore Kenya's cut flowers are popular in Russia or even in the USA.

The floral industry in Kenya is well developed and expanded mainly because of ideal climatic conditions that offer sunny and warm weather. Thanks to this, Kenya can produce flowers even without greenhouses, which are expensive to take care of. Another important advantage of Kenya is that it has a great transport links for export to Europe. An airport in Nairobi is used for the transportation to the rest of the world. As a matter of interest you can find a special terminal for flowers and vegetables here (Veselinovic, 2015).

The economy in Kenya is hugely influenced by agriculture. Gardening sub-sector is one of the most earning sub-sectors of agriculture. It provides around 1 billion American dollars every year. In 2014, flower industry participated with 1.52 % in the national GDP. The volume of floral industry is growing annually. As an example, the production has risen from 10 964 tons in 1988 to 136 601 tons in 2014 (Kenya Flower Council, 2016). Not only floral industry, but also the land that is covered by irrigation crops, is growing as well (Becht, 2007). More than 0.5 million people, including over 90 000 employees, depend on flower industry in Kenya.

Some of the major areas of flower production are around Lake Naivasha (Figure 3), Mt. Kenya, Nairobi, Thika, Kiambu, Athi River, Kitale, Nakuru, Kericho, Nyandarua, Trans Nzoia, Uasin Gishu and Eastern Kenya (Kenya Flower Council, 2016).

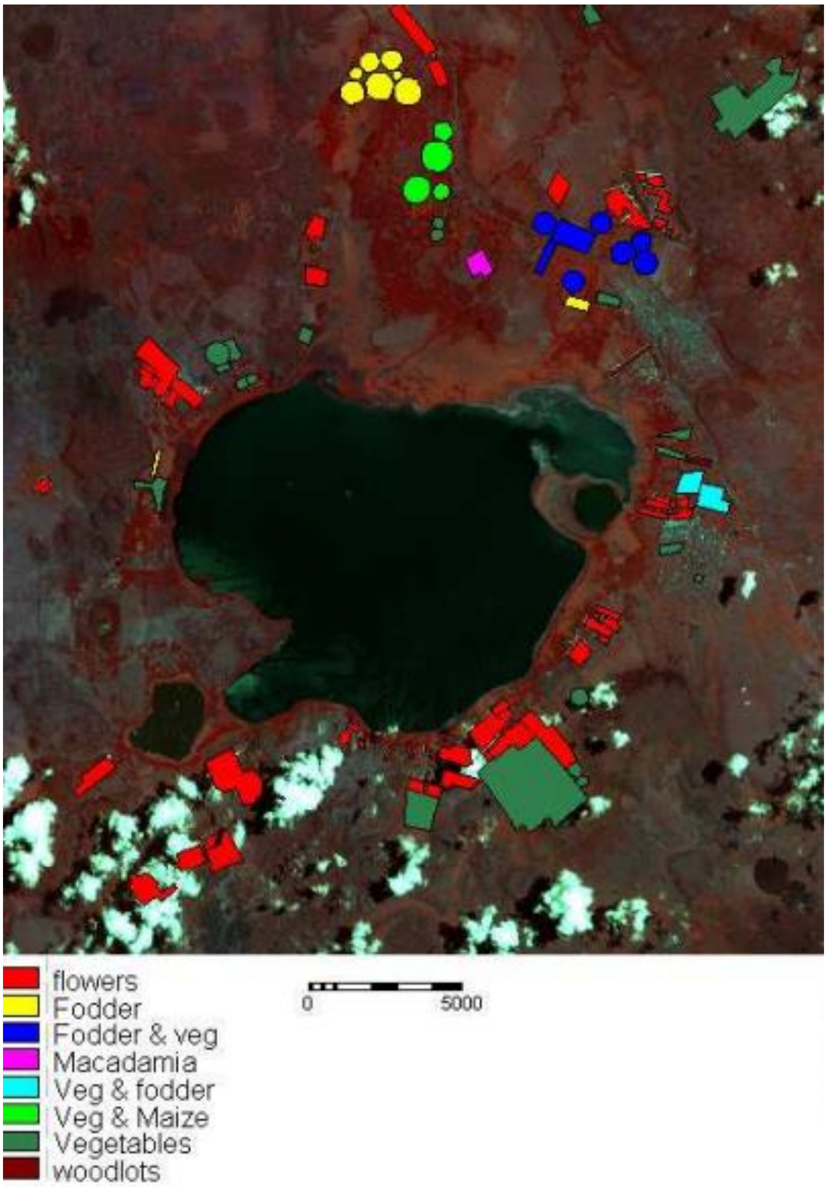

Figure 3: Irrigated crops from Lake Naivasha (Becht, 2007).

4.2.2 Societal impact

One of the most discussed topics about flower farms is the situation of workers and also the conditions in which they work. There were carried out several researches, studies and investigations focused especially on low wages, limits on freedom of association, discrimination and sexual harassment, a large number of casual workers and inadequate health and safety conditions (Gårdman, 2008).

The first important problem is an average wage of worker in flower farm, because it is only 23£ per month, which is not enough to secure basic needs (food, education, medical treatment, housing and transport).

Following to much discussed issue is an employment of women in floral industry sector, which is higher than in any other sector. Investigations also showed that due to insufficient education and experience and negative cultural stereotypes women are stuck in low earnings positions. Management and higher positions are occupied by men. Furthermore there were cases which included even sexual harassment.

Last but not least, there is a focus of researches on health of workers. Use of chemicals is dangerous and causes illnesses and injuries such as skin damages and allergic reactions, respiratory problems, asthmas, headaches, fainting and more. In addition to this, workers who are injured or ill are subsequently made redundant. Workers are not only inadequately trained for use of pesticides and other chemicals, but also they do not have an access to appropriate protective equipment. Moreover it was found that farms do not leave enough time to air the greenhouses and workers have to re-entre the greenhouses too soon (Leipold & Morgante, 2013).

4.2.3 Economic impact

The floral industry in Kenya does not have only negative impacts. It is also positive for some sectors, especially for the economy. The contribution of the floral industry on country’s economy, sustainability of export growth and impact of consumer behaviour are actually the most discussed topics about impact of floral industry on economy in Kenya.

There are several reasons why Kenya has invested into floral industry. However the most important reason is that Kenya has an ideal natural and climatic conditions for flower cultivation.

The floral industry belongs among the top exchange earners in Kenya. Around 50 000 people are directly employed in flower farms and approximately 2 million people are influenced by it. Kenya stands in the third position in export of cut flowers in the world. Over the last 10 years, Kenya has reached 24% growth rate. Thanks to these factors, flower industry is a huge economy contributor in Kenya (Leipold & Morgante, 2013).

4.2.4 Environmental impact

Negative environmental impact of floral industry on Kenyan natural resources is probably the most problematic issue regarding to all negative impacts of this branch. The concrete and the most discussed problems are: unsustainable use of water resources, use of noxious chemicals and pesticides that contaminate water and soils, carbon emissions created by transport of cut flowers and destruction of original nature and water resources.

It is necessary to use water in flower farms and in agriculture in general. However, the most important is to secure a sufficient amount of water for communities. The most delicate area of Kenyan floral industry is around the Lake Naivasha, which is a home of majority of flower farms. Around 60 % of all flower farms in Kenya are located here. According to many explorations, pollution and also decrease of water level in Naivasha Lake is caused mainly by flower farms around it (Leipold & Morgante, 2013).

The flower farms participate in pollution of water resources by releasing dangerously high number of chemical substances and elements into the water. Concretely, pollution by phosphorus and nitrogen is the most problematic and the most expanded. Other sources of contamination from the floral industry are pesticides and herbicides that are extensively used. There are used also several agrochemical means that are harmful for water quality and dangerous for human health. Among widely used agrochemicals belong organophosphates or paraquat (Konrádová, 2015). The positive fact is that significant number of farms are trying to use organic methods of pest management and trying to use fertilizers, pesticides and herbicides more responsibly. The criticism of floral industry also applies to CO_2 emissions from frequent transport with cut flowers to the whole world.

Another often discussed issue is that some farms do not respect the protected natural areas (especially wetlands) and place their grounds there. This behaviour has a negative impact on original habitats. Important wetland is for example the area around the Lake Naivasha (Leipold & Morgante, 2013).

4.3 Water situation and hydrology in Kenya

4.3.1 Basic information

Kenya is a country which suffers from a lack of water and also from water pollution so it demands a lot of sanitation to make it clean and harmless to consumption. Only 2 % of the total country area is covered by surface waters. The availability of water per capita equals about 650 m^3 per year. Estimations for the future predict that by the 2025 this number will drop to 235 m^3 due to the population growth. A poor level of scarcity in some regions is a serious problem in terms of development (Soft Kenya, 2011). Water withdrawal is presented in Figure 4.

Kenya is notoriously known for its low level water management. The condition of water sources was that bad that the most of the Kenya’s budget was invested into the water management even 20 years ago. Considerable part of economy in Kenya is represented by agriculture. It also contributes to water scarcity and water pollution because the agriculture is dependent on fertilizers and irrigation. Moreover, a large number of Kenya’s population does not have access to clean water. Only 55.1 % of rural population had access to clean water in 2012. In the same year, 82.3 % of the urban population had access to clean water (Konrádová, 2015).

An average rainfall is approximately 630 mm annually. However, in the north, the precipitation does not reach more than 200 mm per year. On the other hand, on the Mount Kenya rainfall easily reaches over 1 800 mm per year. More than 80 % of the land area is considered as arid or semi-arid, with an annual average precipitation between 200-750 mm (FAO, 2015).

The revision of the Water Act in 2002 led to innovations and initiation of reforms (Mogaka et al., 2006). Boards of water services realized steps to develop urban water supplies infrastructure in 2009. Meanwhile in rural areas National Water Conservation and Pipeline Corporation secured schemes. Most of these works were focused on enlargement and improvement of the water supply systems. The Kenya Government took part in suppling of clean water as well. The Government provided building water dams especially in rural areas for better availability of water for the local population. The dams were built in several Kenyan districts (Soft Kenya, 2011).

Water use

Water withdrawal:			
Total water withdrawal	2010	3 218	million m^3/year
- Irrigation	2010	1 602	million m^3/year
- Livestock	2010	255	
- Fisheries	2010	42	
- Wildlife	2010	8	
- Municipalities	2010	1 186	million m^3/year
- Industry	2011	125	million m^3/year
• Per inhabitant	2010	78.7	m^3/year
Surface water and groundwater withdrawal (primary and secondary)	2010	3 218	million m^3/year
• As % of total renewable water resources	2010	10.4	%

Figure 4: Water use (FAO, 2015).

4.3.2 Water resources

The Kenyan water resources are represented by the Indian Ocean, landlocked lakes, permanent and also seasonal rivers, wetlands and ponds (Konrádová, 2015).

All of the main rivers in Kenya flow away from the central highlands. These rivers are separated into two groups. The first group are rivers which drain westwards into the Lake Victoria and the second group is represented by rivers which drain eastward into the Indian Ocean. In Kenya, there are five major drainage basins including the Lake Victoria, the Rift Valley, the Athi-Galana-Sabaki River, the Tana River and the Ewaso Ng'iro River (Soft Kenya, 2011). The largest drainage area consists of Ewaso Ng'iro River, which covers 36.3 % of whole drainage area. The second largest drainage area is the Rift Valley, which covers 22.5 %. Next is Tana River, which covers 21.7 %. The last two areas are Athi-Galana-Sabaki River, which covers 11.5 % and the Lake Victoria that covers only 8 % (Konrádová, 2015).

Despite the fact that only a small part of the Lake Victoria is located in Kenya, inflow to this lake from Kenya is 33 % (about 470 million m^3 annually). The Rift Valley is created by several basins that form a system of lakes among which belong the lakes Natron, Magadi, Naivasha, Turkana, Elementaita, Nakuru, Bogoria and Baringo (Soft Kenya, 2011).

4.3.3 Water supply and sanitation

The access to water supply and sanitation in Kenya is not on a high level. It is vice versa. Kenya has a problem also with a bad quality service. Only 9 out of 55 service providers are capable of stable water supply during the whole year. The improvement of water supply is complicated because of seasonal and regional water scarcity.

Thanks to Water Act in 2002, the water sector in Kenya went through some reforms. After this period, provision was separated into 117 Water Service Providers (WSPs). These WSPs are subordinated to eight regional Water Services Boards (WSBs) in charge of asset management service throughout Service Provision Agreements (SPAs). "*The Act also created a national regulatory board (WASREB) that carries out performance benchmarking and is in charge of approving SPAs and tariff adjustments. The Ministry of Water and Irrigation is in charge of policies for water supply and the Ministry of Public Health and Sanitation is in charge of policies for sanitation.*"

Data from Joint Monitoring Programme for Water Supply and Sanitation (JMP) reveal that only 59 % of Kenya's population had access to improved water sources in 2008. 19 % of Kenyans have access to piped water either through a house or a garden according to JMP. Estimations from JMP show that in urban areas the access to improved water sources dropped from 91 % in 1990 to 83 % in 2008. Even so the access in rural areas elevated from 32 % to 52 %. The Impact Report from 2009 reveals that between the years 2006 and 2007 had access to satisfactory and safe drinking water around their homes and at price they can afford only about 37 % of Kenyan population.

Other estimations made by JMP display that 31 % of Kenya population had access to private improved sanitation in 2008 (Soft Kenya, 2011).

4.3.4 Water quality

The state and quality of Kenyan water is in a bad condition in general. Quality of water is connected to population growth and developing industry (Chapman, 1996). Due to these factors, water pollution in Kenya still grows. Population growth brings another problem, which is a higher need of usage of water resources. In other words, population is growing, but water supplies are not.

Also the situation regarding waste water is alarming. Despite that waste water usage is prohibited, a large part of the poor ignores this prohibition. Waste water system and generally whole water management in Kenya is on a low level.

Huge polluter of Kenya's water resources is the agriculture. The agriculture contributes to poor water quality by sewage and garbage from crop and livestock production. An inappropriate use of fertilizers or an incorrect use of methods in farming also negatively affects water quality (Konrádová, 2015). Quality of water is presented in Figure 5.

Parameter	Desired level	1963	1974	1984	1999	2000	2012
Colour	Colourless	Colourless	Colourless	Slightly coloured	Coloured	Highly coloured	
Turbidity **Sediment Load**	Clear nil	Clear nil	Clear slight	Turbid moderate	Turbid heavy	Very turbid heavy	Very turbid
Total Dissolved Solids	Normal	Normal	Fair	Moderate	Moderate increase	Very high increase	Unacceptable <1200 (mg/L)
Bacteriological Contamination	No pathogenic bacteria	Little contamin.	Little contamin.	Little contamin.	Gross contamin.	Gross contamin.	Gross contamin.
E. coli					moderate	polluted	Critical
Total coliforms							Critical
Biological oxygen demand	Less than 5mg/l	5-20	10-20	20-40	40-60	60+	30+

Figure 5: Quality of water in Kenya, 1963-2012 (Konrádová, 2015).

4.3.5 Water problems

Scarcity of water is one of the main problems that Kenya faces right now. Approximately 13 million people in Kenya are missing access to improved water supply. Access to improved sanitation is missing around 19 million of population. Water resources are very important for Kenyans as a source of clean drinking water, but also in terms of agriculture, crops, livestock and fishing.

Among the other problems, which pollutes water, belongs soil erosion that is caused primarily by deforestation. This trend is widespread across the whole country and when you add the other pollutants for example human and animal waste into already polluted water, it makes finding a clean water even more problematic. Slums that arise especially in large cities such as Nairobi, represent an another issue. In these slums people live in the worst conditions and have most polluted water in the whole country.

Kenya is among the countries which suffer most from lack of water in the world. The actual water state has caused many problems including a large number of diseases and conflicts over the remaining resources of clean water. Meaningful improvements in land management and environmental policies are the only ways to help Kenya with this problem and to secure water that needs to become a developed country (Soft Kenya, 2011).

4.4 Technologies for water purification

It is necessary to become acquainted with basic water purification technologies before making choices of adequate purification technologies for polluted water from Kenyan flower farms. This chapter is focused on the most common technologies for water purification and water treatment. There is a basic description of these technologies in the following subchapters. Some of these technologies require the pre-treatment of water. Flocculation, pH adjustment, sedimentation and filtration represent the most used pre-treatment technologies. However, vast majority of water purification technologies can work by themselves (Kubín, 2010).

4.4.1 Filtration

Basically, the filtration is a process which is used for the separation of solids from fluids. It is performed with the help of filter that is responsible for separation. There are many types of filtration. Not all, but the most important of them are mentioned and described here.

Conventional filtration is one of them. This filtration requires three pre-treatment steps. It has to be pre-treated by coagulation, flocculation and sedimentation.

Next type is a direct filtration that requires pre-treatment only by coagulation and flocculation. The particles are removed directly by the filters and sedimentation is not needed here.

Slow sand filtration does not need pre-treatment. It works thanks to fine sand and gravel through which water flows. This type of filtration is simple, reliable and relatively cheap. On the other hand, the main disadvantage is that it can work only with water with low turbidity.

Packaged filtration is simply the combination of flocculation, sedimentation, filtration and chemical addition. Packaged plants are useful thanks to their compact size, cost effectiveness (in consideration of price and quality) and relatively easy operation. Disadvantages appear when turbidity grows. With the higher level of turbidity, it gets more difficult to do filtration.

The membrane filtration is probably one of the most popular types of filtration. This filtration is able to separate various substances from water thanks to membrane through which water flows. It is efficient especially on removal of viruses and bacteria. It can also cope with odors, tastes and colour of the polluted water. The problem of membrane filtration is fouling of the membranes (especially where a high pressure is needed). On the principle of membrane filtration work four processes. These processes are microfiltration (MF), ultrafiltration (UF), nanofiltration (NF) and reverse osmosis (RO). Microfiltration uses membrane with size of pores between 0.03 and 10 microns. Operating pressure range reaches from 100 to 400 kPa. MF is not capable of removing a considerable amount of viruses which is the main disadvantage of this process. Ultrafiltration uses membrane with pore size from 0.002 to 0.1 microns. The operating pressure range is between 200 and 700 kPa. Nanofiltration uses membranes that have a size of pores approximately 0.001 microns. Operating pressure has to be high, range reaches from 600 up to 1000 kPa. Thanks to this NF can remove all viruses, bacteria, cysts and also organic material. The another advantage of nanofiltration is that it can remove alkalinity. Reverse osmosis is a method that also uses high pressure to push water through membrane. It is effective in elimination of almost all organic and inorganic pollutants from water, such as radium, natural organic substances, bacteria, viruses, cysts and pesticides. Systems that use high pressured membranes are very efficient, but this high pressure can damage membranes. The next disadvantage is a high energy consumption of these systems. The higher pressure is, the more energy is needed (Kubín, 2010).

4.4.2 Disinfection

Primary methods of disinfection include ultraviolet light radiation, ozone disinfection and chlorination.

Ultraviolet light radiation is generated by special lamps. It is effective especially in elimination of bacteria and viruses which are killed by this radiation. The disadvantage is that ultraviolet light radiation is unable to kill all cysts (e.g. *Cryptosporidium* or *Giardia lamblia* cysts). This purification method is also inappropriate for waters with high amount of suspended solids, high turbidity and colours.

Disinfection by ozone is the method based on principle of strong oxidizer that needs only a short reaction time (few seconds). It is efficient for removal of viruses and algae. This process also oxidises iron and manganese. The another advantage is that ozone disinfection eliminates all organic particles, colours, taste and odours from water.

On the other hand, the installation of this system is very complicated and purchase price is very high.

Chlorination is a process that uses chlorine (gas or powder form) as disinfection mean for water purification. Use of chlorination has two main advantages which are availability and reactivity of chlorine. Presence of chlorine on Earth is high, so the production is relatively cheap. There are several disadvantages of use of chlorine. A very high toxic potential of chlorine is one of them. Also, a high concentration of hypochlorous acid in water can be problematic. It creates skin and eye problems to some people.

After the treatment by ultraviolet light radiation or ozone, it is necessary to use secondary disinfectant for prevention of regrowth of microorganisms (Kubín, 2010).

4.4.3 Electrode-ionization

Also known as electro-dialysis is a technology that uses electric field for water purification. An electric device creates electric field between catode and anode which causes the exchange of ions in water. This method eliminates all contaminant ions and vast majority of the dissolved inorganics. The problem is a purchase price which is very high. However, further work with this system is cheap. Important is that water needs to be pre-treated before electrode-ionization process (Kubín, 2010).

4.4.4 Package plants

Package plants represent combination of several water purification or water treatment technologies in one unit (e.g. disinfection + filtration + electrode-ionization). The advantages of package plants are mainly about financial aspects. Initial costs are not high and maintenance and further operation are also relatively cheap. The efficiency of these plants depends on their construction and their concrete parts. However, in general package plants are efficient in elimination of turbidity, bacteria and dissolved substances from underground water. There can appear complications with transport to some areas, in this case presence of experienced operator is required (Kubín, 2010).

4.4.5 Organic removal

Among the most efficient technologies for removal of organic pollutants belong activated carbon method and aeration method.

Activated carbon technology uses a large network of internal pores that were created thanks to high temperatures. There are two variations of activated carbon. The first one is a granular activated carbon. The second one is powdered activated carbon. The main disadvantage of this technology is potential growth of bacteria on top layer.

Aeration is a method that mixes air and vapour to get rid of contaminants. There are several types of aeration, for example diffused aeration, column aeration, multiple-tray aeration and more. Aeration is capable of organic chemicals removing, but it can eliminate radon as well (Kubín, 2010).

4.5 Possible technologies for water purification at flower farms in Kenya

4.5.1 The constructed wetlands

Natural wetlands are often described as earth's kidneys because of their ability to filter pollutants from contaminated water which flows through them. So it is obvious that wetlands improves water quality and thus have a positive environmental impact. Thanks to this ability of natural wetlands, groups of scientists and engineers designed models of constructed wetlands (CWs). Scheme of constructed wetland is shown in Figure 6.

Natural wetlands provide a wide range of functions from which can benefit both, environment and people. The most important of these functions is water filtration. Water that is flowing through a wetland is decelerated and a large number of suspended solids are settled by roots of wetland plants. Other pollutants that are not settled by plants become inactive or are converted to less soluble forms. Wetland vegetation also supports the presence of microorganisms. These microorganisms also take part in improving water quality by removing some pollutants out of water. Nutrients represent a large group of water pollutants. Some of them such as phosphorous or nitrogen are often absorbed by soils and then used by wetland vegetation and microorganisms. As an example can be used a function of some wetland microbes. They can convert an inapplicable organic nitrogen to usable inorganic forms (NH_3 and NH_4).

Wetlands belong among the ecosystems with the most biological and productive diversity on earth. Not all of the CWs are exact copies of natural wetlands, but it is useful to build CWs because of their positive impact on wildlife habitat. Constructed wetlands are cost-effective and technically practicable option for wastewater purification. Financial requirements for building CWs are predominantly lower than for building other traditional wastewater facilities. Other advantages of CWs are that they have low operating and maintenance, can handle fluctuation of water levels and can reduce or even eliminate wastewater smell. Last but not least, the advantage of constructed wetlands is their aesthetical aspect.

Building of CWs is generally realized on uplands and outside floodplains in order to avoid a negative impact on environment, especially on natural wetlands and other water resources. "*Wetlands are frequently constructed by excavating, backfilling, grading, diking and installing water control structures to establish desired hydraulic* *flow patterns. If the site has highly permeable soils, an impervious, compacted clay liner is usually installed and the original soil placed over the liner. Wetland vegetation is then planted or allowed to establish naturally*" (EPA, 2015).

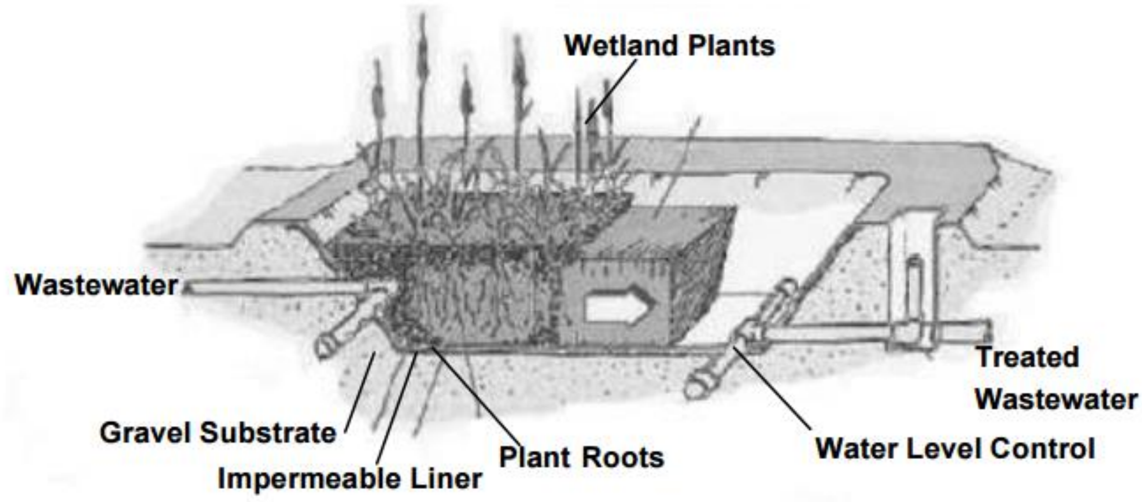

Figure 6: Scheme of constructed wetland (EPA, 2015)

There are currently six working CWs in Kenya. All of them are placed around the Lake Naivasha thanks to the location of flower farms in this area. These constructed wetlands were built by some of the providers of flower farms in order to protect the lake and surrounding nature from pollution that flower farms cause.

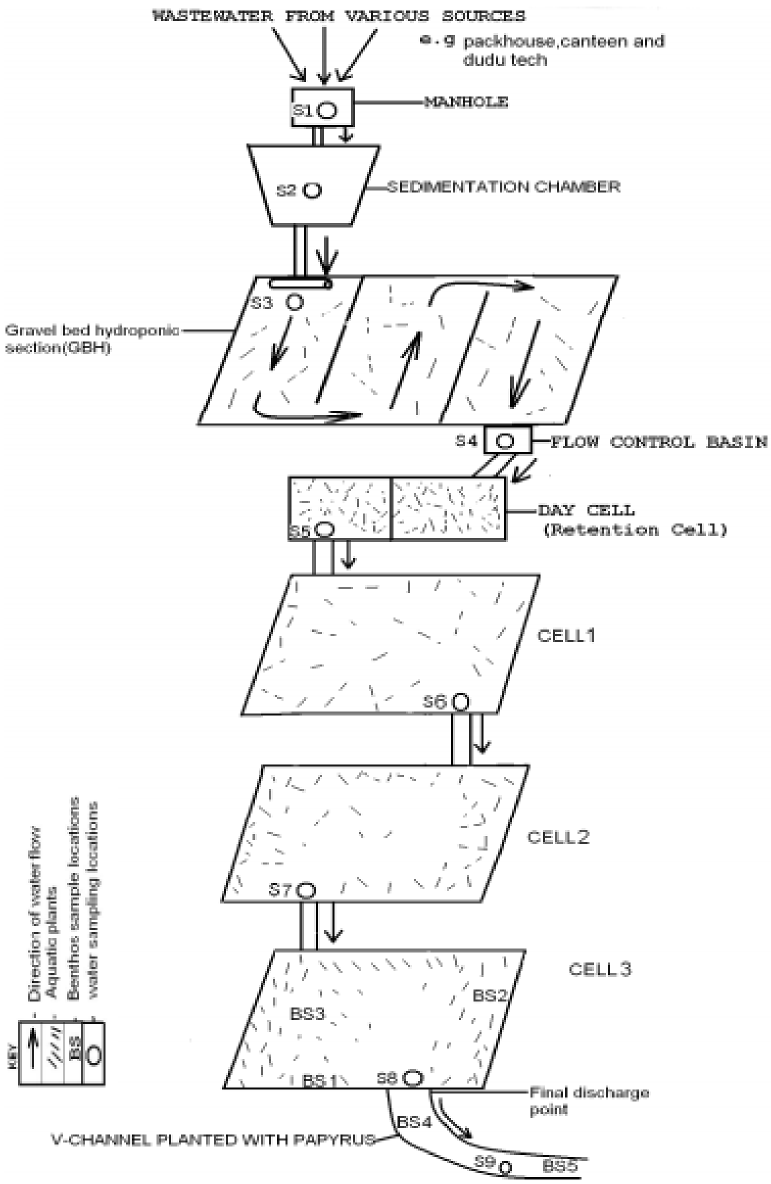

Figure 7: Scheme of Kingfisher constructed wetland (Kimani et al., 2012).

The Kingfisher constructed wetland[1] (Figure 7) is one of these six wetlands. The construction of this wetland was completed in 2005 for the price around 40 000 American dollars. The capacity of the Kingfisher constructed wetland is designed to receive approximately 45 m^3 of polluted water every day. Wastewater gets into the wetland from various sources, but mainly from nearby flower farms. This wetland is represented by combined (hybrid) system that is a combination of two systems.

[1] S1-inlet, S2-sedimentation chamber, S3-inlet GHB, S4-outlet GBH, S5-outlet day cell, S6, S7, and S8 are outlets cell 1, 2 and 3 respectively S9-v-channel (Kimani et al., 2012)

Subsurface flow system also known as gravel bed hydroponics (GBH) section and a surface flow system that consists of three sequential treatment cells (Konrádová, 2015).

Water that is entering inlet is exposed to direct sunlight and fresh air for the first time. This process causes fast appearance of green algae which is a positive sign. After this, water continues into the sedimentation chamber to gravel bed hydroponic (GBH) section. Gravel bed hydroponic section is represented by rectangular area that is bounded by walls. Inside this area are also placed alternating wall embankments. Thanks to them wastewater can coil through gravel while the water breakdown is happening. The microbial breakdown of organic wastes is realized with help of huge surface area for the microbial attachment ensured by ballast pieces. Top of the GBH is covered by macro hydrophytes that are able to absorb nutrients and help in the transport of oxygen to the useful underground bacteria colonies. The same applies to wetland cells two and three. Cells one, two and three have open surfaces at their midpoints because of facilitation of natural aeration. Pathogenic organisms are destructed thanks to ultraviolet irradiation. The CWs around the Lake Naivasha are equipped with riparian buffer installations that serve to agrochemical removal.

The main goal of constructed wetlands is to improve water quality by removing harmful and dangerous nutrients or other noxious substances. Although the process of wastewater filtration in CWs helps to improve water quality, water still contains a large number of nutrients even after filtration. Higher efficiency of CWs can be reached by combining of different types of constructed wetlands together (Konrádová, 2015).

4.5.2 Technologies for reducing agrochemicals

There are many other ways that can be used for water purification at flower farms, not only by constructed wetlands. Technologies that use membrane processes for agrochemical removal represent one of these ways. Ultrafiltration, microfiltration, nanofiltration and reverse osmosis belong into this group. All of these methods mentioned above are based on selective permeability of the membrane. This permeability depends on the size of membrane pores. Thanks to membrane processes these technologies are useful especially for reduction of pesticides.

It is because of ability of nanofiltration membrane that is able to filter molecular weights from 200 to 15 000 g/mol and molecular weights of pesticides reaches only between 200 and 400 g/mol. Surface waters can be effectively get rid of organic and also inorganic substances by NF which is another advantage of this method. For the reduction or removal heavy metals from water is more effective reverse osmosis. For treatment of underground waters and for treatment of lake water is mostly used the ultrafiltration.

Efficiency of microfiltration can be described on example from Italy where several test were made on water from Lake Brugneto. Results from these test showed very positive signs. Tests confirmed that MF had 100 % efficiency in removal of pathogenic microorganisms and 99.2 % efficiency in elimination of all types of algae.

Although all these membrane processes represent very efficient way of water purification, they are very demanding in energy and maintenance. Also financial demands, especially initial investment into the pumps, are very high. Considering these facts, it looks that this way of water purification is not suitable for Kenya, but some companies (especially from India) offer nanofiltration plants for affordable prices (Konrádová, 2015).

4.5.3 Water saving technologies

Flower farms use a large amount of water for their irrigation from natural resources such as lakes, rivers or even the groundwater. If this trend continues, it is necessary to focus on saving water in these natural resources. The size of area irrigated from these three main sources reaches 4467 ha. Water from lakes represents 55 %, groundwater represents 39 % and water from rivers represents only 6 % of irrigation from natural resources (Becht, 2007). Draft National irrigation policy of Kenya has plans for improvement of Kenyan drainage system until 2030 (Konrádová, 2015).

Among the most used irrigation systems in flower farms these days belong sprinklers, pivots and drips (Becht, 2007). There have been some innovations in the irrigation technologies over the last 20 years. Changes apply to transition from overhead sprinklers to more superior and modern technologies such as pivots and drips. A large number of farms also changed outdoor cultivation for greenhouses. The advantage of greenhouses is that there can be used the newest technologies. As an example of this technology can be used hydroponic systems. These changes and improvements considerably help to preserve water (Konrádová, 2015).

Jain Irrigation Systems Ldt. is one of the companies that offer many types of irrigation systems. Jain Jyot Solar Water Pumping System is one of them. It works on principle of power generated by solar photovoltaic panels. "*The power generated by Solar Panels is used for operating Solar Submersible pump for lifting water from open well, water reservoir or tube well for irrigation and drinking water purpose. The system requires a shadow-free area for installation of the Solar Panels.*" This system can be combined with other systems, for example with rainwater harvesting (JAIN, 2014).

Groundwater harvesting is another method that saves water. It works with a method of water collection from surface runoff and storing it in surface reservoirs. This method substitutes lakes. The accumulation of water is secured by sloped channels that go straight into the retention tank. It is recommended to build the tank from impervious materials in order to prevent water contamination from soil. It is also recommended to build it into the ground because of lower material costs.

Water harvesting is used also in combination with treatment technologies. Example of a treatment technology is technology based on help of seeds from *Moringa olifera* that is used especially in the western part of Kenya, concretely in Nyatike district. Purification technology which is using MOCP is primarily effective against medium and high pollution levels made by mud, clay and bacteria. It is based on ability of ion exchange. Positively charged proteins can attract negatively charged particles and bacteria. This process causes that these opposite particles link together. It is important to count with the fact that treated water could not be stored at reservoir tanks for a long time. For this reasons scientists came up with idea of f-sand technology. This method also includes positively charged proteins from *Moringa olifera*, but these proteins are added into the negatively charged f-sand. The main advantage of this technology consists in elimination of organic matter that is consumed by microorganisms. The result of this process is a clean water that can be stored for longer time. This f-sand technology for water purification can be used in the rainfall water reservoirs or in sand filters (Konrádová, 2015).

4.5.4 Water purification plant

There are countless combinations of purification technologies from which water purification plants can be built. This subchapter describes possible construction of water purification plant for treatment of polluted water from flower farms in Kenya. This proposed plant consists of four main units. These units are (the sequence of units is in order in which water enters them):

1. Electrocoagulation unit
2. Central purification unit (CPU) and mixed media filter
3. Sand filter
4. Superstructure

The combination of these four components guarantees an efficient and quality water purification. Each of these units represent a reliable and functional option of water purification. It has been proved before in other countries of the world. The final product of this plant is a clear and drinkable high quality water.

Electrocoagulation unit uses electrocoagulation as a water treatment. It uses a principle where charged particles, located in colloidal suspension, are neutralized by mutual clash with counter ions and piled up. These processes are followed by sedimentation. The coagulant is often constituted by some chemical substance, especially alum is widely used. Electrolysis means that the positively charged side is under anodic reaction and vice versa with negatively charged side which is under cathodic reaction. This causes release of ions that neutralize charge of particles. After these processes, the coagulation begins. Harmful elements are eliminated by released ions.

CPU is a pre-engineered plant. Scheme of CPU is shown in Figure 8. Function of this unit is based on the same methods that use the basic water purification technologies. Central purification unit uses a chemical coagulation, flocculation, sedimentation and settling tank. After these processes a cleared water flows into the mixed media filter. This filter is filled with at least three types of granular material of different size (e.g. silica sand, anthracite, fine gravel, carbon, etc.). The coarsest materials are located on top and the finest materials are located underneath. This structure secures resistance even against cyst forming bacteria such as *Cryptosporidium* and *Giardia lamblia*.

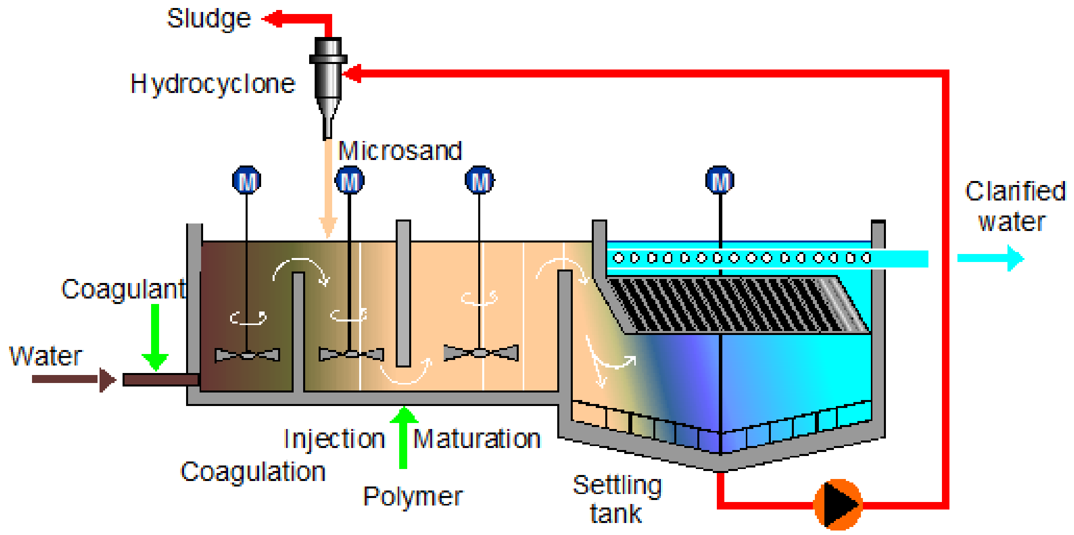

Figure 8: Scheme of CPU (Kubín, 2010)

Sand filtration is a method that uses pressure single-chamber filling filter (PSFF) system. This system filters water from remaining substances or substances created during flocculation process. Backwashing or reverse water flow is possible way of filter cleaning (Kubín, 2010).

Superstructure uses ioniser device, concretely IVK II. It is based on electrolytic release of silver ions into the water. Thanks to disinfection effects of this technology, it is efficient especially against pathogenic bacteria such as *Tyfus-paratyfus, Vibrio cholerae asiaticae, Legionella pneumophila, Lamblia intestinalis, Cryptosporidium parvum, Escherichia coli, Salmonela enteritis, Salmonella typhi, Enterococcus – faecalis, faecium, avium* and more (PROTE, 2016).

The problem of this superstructure technology is that the price is high because of the device for water purification that uses silver. However, without this unit, plant would be less effective and the quality of water would be distinctly lower. There are two possibilities. Either, pay higher price and gain safe and drinkable water or leave this unit and use plant that has only three previous units. Without this unit water would not be drinkable, but it would be usable for agriculture. It depends on further use of water (Kubín, 2010).

5 Conclusion

As mentioned above in the thesis, Kenya is a country that does not have sufficient amount of water. Kenya suffers not only from scarcity of drinkable water for its population, but also from scarcity of water for other purposes (for example a lack of in water industry or in agriculture). Therefore Kenya should not waste water from its natural water resources and also should take care of them. This care should include avoiding water pollution, improving water quality by purification and what is very important is reusing purified water. The technologies that purify water should return it back to flower farms for repeated utilization. The protection of Kenyan water resources can be done by many ways. It does not matter which methods will be used, but Kenya has to take care of its natural water resources if wants to improve its water situation in general.

This thesis is focused on water pollution from flower farms. In general, agriculture consumes a large quantity of water and returns it back to the natural resources greatly polluted. The problem is that this water is used again and repeatedly polluted. So, the agriculture causes not only decrease water, but also higher and higher pollution. This behaviour can lead to serious problems so it should be solved. It is not different with flower farms conversely it is exactly the same case. The flower farms pollutes nearby water resources such as lakes, rivers or groundwater with undesirable substances of different composition and origin. This pollution originates from various fertilizers, chemical sprays and other means used at flower farms. The main pollutants which flower farms contaminate water with are phosphorus and nitrogen. Also water contamination is caused by other substances, such as pesticides or agrochemicals. Among the most used agrochemicals that pollute water belong organophosphates or paraquat.

Due to these contaminants water in the natural resources becomes less usable and more dangerous also for other branches of agriculture or industry. Last but not least, human lives are affected by this pollution. Contaminated water from flower industry should be somehow purified, because it can be very problematic if the water will not be treated. And that is the main aim of this thesis, to suggest technology for water purification that can be used at flower farms. The thesis offers the list of basic technologies that are used for water purification, and also concrete treatment technologies suitable for flower farms. There are several suggestions. The first of these proposals is technology called constructed wetland. Next are various types of filtrations such as ultrafiltration, microfiltration, nanofiltration or reverse osmosis. There have also been mentioned technologies that are able to save water. Among these methods belong for example a simple use of more superior and more modern pivots and drips, irrigation systems such as Jain Jyot Solar Water Pumping System and more. The bachelor thesis even includes the proposal of water purification plant constructed from four units. All of these methods and technologies are described in detail in previous chapters. This description includes how these technologies work, what are the advantages and disadvantages, against what pollution they are effective and other information.

The main problem is that some of these technologies purify water not from all contaminants, others are more efficient but maybe too expensive for Kenya and others can't be used in some areas. There are definitely more issues that relate to finance, location, workers and so on, but that is nor the topic neither the aim of this bachelor thesis.

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Appendix

Figure 9: Worker at flower farm Maridaidi in Naivasha (Veselinovic, 2015).

Figure 10: Flower farm worker at her workplace (Njagi, 2013).

Figure 11: View of flower farms around Lake Naivasha (Dutch Water Sector, 2012)

Figure 5: Harvest of flowers in Kenyan flower farm (Epatko, 2010).

Figure 13: Greenhouses for flower cultivation (Flowerweb, 2014).

Figure 14:Contamination of Naivasha Lake (Martín-Borregón, 2014)