

CZECH UNIVERSITY OF LIFE SCIENCES PRAGUE
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DIPLOMA THESIS

**STUDY OF THE IMPACT OF BOGOTÁ CITY
ON THE ENVIRONMENT AND PROPOSAL OF
BETTER SOLUTION OF WASTEWATER
TREATMENT AND WASTE MANAGEMENT**

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Prague, 2012

Declaration

I hereby declare, that I have written this diploma thesis myself with help of the literature listed in references.

Prague, 15th April 2012

Bc. Filip Šinágl

Acknowledgement

I would like to thank my supervisor that he helped me to elaborate this diploma thesis.

Motto:

Above the shield of the national emblem of Colombia sits condor with a laurel wreath and a gold ribbon with a Spanish inscription "Freedom and order." Do condor wings expanding above the capital of Colombia see the promised order?



Annotation

Abstract:

This thesis deals with a waste management and treatment of wastewater in the city of Bogotá and related issues of the environmental protection. Bogotá city is the capital of Republic of Colombia (*República de Colombia*) in South America. The motive of the thesis is putting principles of sustainable development into the practice. The aim of the thesis is to determinate the current status of waste management and water pollution in the city of Bogotá, assess the potential impacts on the environment and local agriculture and to find any appropriate solutions to remedy. Investigating the problem involves the study of the legislation, available information from credible sources and personal on-site survey, which was adapted to the possibilities and conditions of movement of foreigners in this country. Author of the thesis studied the history of the city and recognize the natural conditions of Bogotá city and its surroundings. The author visited state and municipal institutions responsible for the examined area and interviewed local people. The status was investigated by personal fieldwork and the photographic documentation was taken where it was possible because of the personal safety. In the introduction of the thesis is summarized basic knowledge of Colombia, Bogotá city, natural conditions, demographics and the character of local agricultural activities in the Bogotá city and surrounding. The knowledge of these facts is necessary to understand all connections. The thesis focuses on findings of how works a system of disposal of municipal solid waste and how is ensure cleaning of the wastewater. It was also examined whether this issue affects agricultural activities and how citizens perceive the problematic of the given topic. The author prepared and organized a survey among local residents to determine their motivation to environmental issues and their willingness to participate in potential improvements of the current situation. The author deals with a pollution of the river Bogotá which runs through the capital of Colombia. The thesis includes a proposal to reduce water pollution in the river by finding a suitable wastewater treatment system of Bogotá city and proposal of better waste management. In conclusions the author summarizes the basic knowledge on the matter.

Keywords:

Colombia, Bogotá, environment, wastewater, municipal waste, agriculture

Anotace

Abstrakt:

Tato diplomová práce se zabývá nakládáním s odpady a čištěním odpadních vod v městě Bogotě a s tím souvisejícími otázkami ochrany životního prostředí. Bogotá je hlavní město Kolumbijské republiky (*República de Colombia*) v Jižní Americe. Motivem práce je uvádění zásad trvale udržitelného rozvoje do praxe. Cílem práce je zjistit současný stav a zhodnotit možné dopady ukládání odpadů a znečištění odpadních vod v městě Bogotě na životní prostředí a na místní zemědělství a pokusit se najít vhodná řešení k případné nápravě. Zkoumání problematiky zahrnuje studium legislativy, dostupných informací z důvěryhodných pramenů a osobní zjišťování na místě přizpůsobené možnostem a podmínkám pohybu cizinců v této zemi. Autor diplomové práce studoval historii města a poznával přírodní podmínky města Bogoty a jeho okolí. Navštěvoval státní a městské instituce zodpovědné za zkoumané oblasti, dotazoval se místních lidí. Zjišťoval stav na místě osobním šetřením v terénu a pořizováním fotodokumentace tam, kde to z důvodu osobní bezpečnosti bylo možné. V úvodu diplomové práce jsou shrnuty základní poznatky o Kolumbii a o městě Bogotě, o přírodních podmínkách, demografii a o charakteru zemědělské činnosti v okolí města Bogotá. Znalost těchto skutečností je nezbytná k pochopení všech souvislostí. Práce se zaměřuje na zjištění, jak funguje systém likvidace pevného komunálního odpadu a jak je prováděno čištění odpadních vod. Bylo dále zjišťováno, zda tato problematika ovlivňuje zemědělskou činnost a jak je vnímána obyvateli města. Autor sám zpracoval a zorganizoval anketu mezi místními obyvateli za účelem zjištění jejich motivace k otázkám ekologie a jejich ochoty podílet se na případném zlepšení současné situace. Autor se zabývá znečištěním řeky Bogoty, která protéká hlavním městem Kolumbie. Práce obsahuje návrh na omezení znečištění vody v řece hledáním vhodného systému čištění odpadních vod města Bogoty. V závěru práce jsou shrnuty základní poznatky autora k dané problematice.

Klíčová slova:

Kolumbie, Bogotá, životní prostředí, odpadní voda, komunální odpad, zemědělství

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List of Abbreviations

| | |
|---------|--|
| ALADI | „ <i>Associação Latino-Americana de Integração</i> “ – International Organization for Latin American free trade |
| AMSL | Above mean sea level |
| CAR deC | „ <i>Corporaciones autónomas regionales de Colombia</i> “ – Colombia’s regional autonomous corporations |
| CAR | „ <i>Corporation Autónoma Regional de Cundinamarca</i> “ - Regional Autonomous Corporation of Cundinamarca |
| CGR | CGR Doña Juana („ <i>Centro de Gerenciamiento de Residuos Doña Juana</i> “ – Economic waste centre Doña Juana |
| Decreto | decree, regulation |
| ELN | „ <i>National Liberation Army</i> “ – National Liberation Army |
| Etc. | Et cetera (a Latin expression meaning „and other things“, „and so on“) |
| e.g. | Exempli gratis (a Latin expression meaning „for the sake of example“) |
| FARC | „ <i>Fuerzas Armadas Revolucionarias de Columbia</i> “- Colombian rebel ultra-left organization that leads guerilla war against the government |
| HDPE | High – density polyethylene (microtene) |
| LDPE | Low – density polyethylene (polythene) |
| Ley | law |
| LFG | Landfill Gas |
| OAS | The Organization of American States |
| UAESP | „ <i>Unidad Administrativa Especial de Servicios Públicos</i> “ Special Administrative Unit of Public Service |
| WWTP | Waste Water Treatment Plant |

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1 Introduction

This diploma thesis originated from the author's interest of Colombia, which he had the opportunity to visit several times in the years 2009 – 2011, out of the respect for its history and immense natural richness, as well as an acknowledgement to citizens of Bogotá city, who had been instrumental in gathering information in terms of which are demanding for a foreigner from Europe. The purpose of this thesis is to find out how big impact has the capital of Colombia, Bogotá, on the environment, how is solved the problem of wastewater treatment and waste management. The author tries to identify problematic areas and suggest improvements. Furthermore, the author would like to thank in this place to the supervisor of this thesis, who enabled him to handle this work.

1.1 Political geography of Colombia

Colombia is a country located in the South America and is a part of Caribbean South America. Colombia is a gateway to south american continent and certainly part of the route, by which came first humans migrating from North and Central America (Babková,2008). This South American county is named after the famous explorer Christopher Columbus who, however, never reached Colombia (Babková,2008). Colombia has an area of 1.138.910 km² (Lexikon,2003, s.100). In terms of biodiversity, particularly flora, Colombia occupies together with Mexico and Indonesia first three places in the world (Staňková,2008).

Colombia has as the only South American country a coastline on both oceans, the Atlantic Ocean and Pacific Ocean. Colombia borders with Venezuela, Brazil, Peru and Panama. The population exceeds 43 millions (Landmann,2009). The capital city is Bogotá and official language is Spanish (Svetdnes,2010).

Colombia is a democratic presidential republic and it is a unitary state with a decentralized management. The current political system came into being by adoption of the Constitution in 1991 (Kolumbie, vnitropolitická charakteristika, MZV,2012). Under the rules of national constitution is elected president, vice president, Congress and the regional council. With a onset of the president Alvaro Uribe in 2002 was improved Colombian international status for his uncompromising military approach to solve the international political situation. His government is associated with an open armed struggle against the FARC and

ELN guerrillas, pressure on human rights and the fight against drugs and its associated terrorism. Politics of Colombia is characterized by an interest on social sector (Kolumbie, vnitropolitická charakteristika, MZV,2012).

The governing authority in the country is divided into three spheres: executive, legislative and judicial. The judicial represent the Constitutional Court, Supreme Court, Office of the Attorney General and the Council of State. The head of the Colombian government, composed of thirteen ministers, is the president of the Republic. The head of each of 32 departments (spanish *departamento*) is governor. Congress consists of Senate and House of Representatives. Regional authorities in Colombia have a partial autonomy. For public administration are important Colombian territorial self-governing corporations (CAR deC), which are always set by law, These corporations are responsible for implementing laws.

1.2 History of Colombia

History of Colombia according to excavations and archeological finding date back to around 3000 BC. In the 15th and 16th century the territory of present-day Colombia was a Chibcha empire, which disappeared after the arrival of the Spaniards in 1528 (Lexikon,2003, s.100). The first conquistador who entered a Colombian land was a Spaniard Alfonso de Ojeda in 1499 (Babková,2008). Spaniards began conquering the territory of Colombia and established some cities such as Cartagena, which became their main commercial center. Thence, along the river Magdalena, continued colonization further inland. Bogotá, the capital of present-day Republic, was established in the year 1538 (Saldarriaga,Gómez,2011). In the year 1549 was set up a Spanish colony (Lexikon,2003, s.100).

In 1717 originated from Colombia, Panama, Venezuela and Ecuador, the new viceroyalty of *Nueva Granada* or New Granada. At the end of the 18th century begun open protests and rebellions against the Spanish domination. In the early 19th century country had declared independence, but subsequently the country was re-occupied by Spaniards (Babková,2008). Spaniards were defeated by battle of Boyacá on 7th August 1819, the large part of New Granada was liberated and incorporated into the newly formed Federation of Great Colombia, which as well included Venezuela (Lexikon,2003, s.100). Independence was reaffirmed and venezuelan general Simón Bolívar, became a hero

fighting for freedom and was elected as a president of Great Colombia (Babková,2008). Colombia along with Venezuela formed the Republic of Colombia. In 1821 Panama joined Republic of Colombia and Ecuador joined in 1822. The president was again elected Simón Bolívar. Colombians definitely defeated Spaniards in 1824 by battle of Ayacucho and Sucre. The centralized system was not able to govern so extensive and diverse territory, and therefore the Great Colombia was split into three separate states in 1830 (Babková,2008). After the disintegration of the federation on January 1831 was declared the Republic of New Granada (Now Colombia and Panama), which in 1886 adopted the name of Colombia. Whole 19th and 20th century is characterized by civil wars. Between years 1863 and 1885 there were in total eight civil wars and more than 50 anti-government insurrections. One of the best known war is so called „One thousand day war“ (1899 – 1902) in which were killed nearly 100.000 people. The period of unrests and bloody wars ended in 1903 when Panama seceded from Colombia (Lexikon,2003,s.100). Colombians recognized the secession of Panama canal in 1921.

Modern history of Colombia is full of coups and frequent alternation of governments. In the year 1948 the assassination of liberal politician Jorge Eliécer Gaitán led to the civil war known as „*La Violencia*“. In 1957 an Agreement was signed, which was confirmed by referendum known as „*Frente Nacional*“ or. During the term of this Agreement political parties were exchanging the presidency in four-year intervals (Babková,2008). Nevertheless in this relatively quiet period appeared complications in connection with the emergence of guerrilla groups. These groups are the oldest rebel forces in Latin America and still continue with armed struggles against the government. In Colombia there are about twelve guerrilla groups. Each group has its own ideology and its own political and military strategy (Babková,2008).

The political situation in Colombia has improved under the presidency of Alvaro Uribe between years 2002 and 2010. The current president of Colombia is Juan Manuel Santos Calderon, who continues the policy of forceful suppression of the drug mafia (Juřík,2010). The country is a member of the UN, OAS and other international organizations.

1.3 Natural conditions of Colombia

Colombia lies in the tropical zone, on the shores of Caribbean Sea and Pacific Ocean. West coastline borders three ridges of Andes, reaching heights of approximately 4.500 m. In the

valleys between ridges of Andes flow two important Colombian rivers - Cauca and Magdalena. The highest mountain of the country does not lie in the Andes but in the Caribbean plateau, known as Cristóbal Colón with its altitude 5.775 m AMSL (Staňková,2008).

In the Southeast are tropical forests of Amazonia. Flora reminds at the altitude of 4.000 m AMSL flora of temperate zone.. In the interior, which is located in the precipitation shadow of the Andes, are located biotops of semi deserts and grassy moors - *paramos* (Ottův ilustrovaný atlas světa,2009).

The climate of the country is generally influenced by altitude. Total precipitation in the north of the country is minimal, in the central areas the precipitation increases to 1.050 mm and at the Pacific areas precipitation reaches 7.100 mm. The rainiest days are from April to May and from October to November. Average temperature at higher altitudes of central areas reaches 14°C and in other areas of Colombia throughout the year is 28°C. The average temperature in Bogotá city is 18°C, due to its high altitude (Allmetsat,2012).

Colombia is ranked with its 25.000 – 30.000 native species of plant among the top three countries in the world in absolute diversity of flora. Just for interest, Czech Republic has about 3.000 plant species of which 500 were implemented (Staňková,2008). So, Colombia could be with a little exaggeration marked as a treasury of nature of Earth. As every real treasure is often in danger, the Colombian nature is as well endangered – population of Colombia is constantly increasing and the pressure on use of natural resources for commercial purposes is high (Staňková,2008).

2 Literature Review

How the city of Bogotá copes in the issues related to waste management, wastewater decontamination, environmental protection and how deals with a problematics in specific cases, was determined from available literature and by the personal conduct in Colombia. In the cooperation with local authorities were surveyed experience of real projects. The survey was also realized among residents of Bogotá city. This survey examined how people perceive the issues related to waste management, waste water management and their interest of this problematic. The diploma thesis include the study of existing legislation.

2.1 The capital of Colombia - Bogotá D.C.

The city of Bogotá is the capital city and the largest city of Colombia. Bogotá city and surrounded areas form together Bogotá D.C. - *Bogotá distrito capital* (Bogotá capital district) which lies in the region of Cundinamarca. Colombia has 32 regions and one capital district. According to the Statistical Office „*Departamento Nacional de Estadística — DANE*“ from 2005, the population of Bogotá D.C. reached 6.778.691 inhabitants (Pliego 001 de 2011). In 2017, on the base of these data, Bogotá D.C. will reach 8.112.294 inhabitants, according to annual population growth 1.48% (Pliego 001 de 2011). The city was founded in the year 1538 at the altitude of 2.640 metres AMSL and carried name Santafé. The city was based on the place of the small indigenous settlement of *Muisca*, a large group of *Chibcha* speaking indigenous cultures. Santafé was from the beginning the capital of the New Granada. In 1819 Santafé was renamed to Bogotá after when Simon Bolivar had become the president of a new Republic. In 1821 Bogotá was chosen as the capital of the Republic. Bogotá is a center of cultural and social life in Colombia and every year many people come to the city look for the work (Saldarriaga,Goméz,2011). It is a center of cultural and social life in Colombia and every year many people come to the city look for the work. It is logical that the life of so populated city has an adverse impact on the environment, producing large amounts of waste and considerable amount of wastewater discharged into the river Bogotá. Bogotá river forms a boundary between Bogotá D.C. and region of Cundinamarca (Ottův ilustrovaný atlas světa,2009).

As in all Colombia, inhabitants of Bogotá D.C. are divided into six social classes, castes - „*Estratos*“ (Figure 5). These social classes are classified according to the property intended for housing within the municipality or region, based on characteristics of housing and socio-economic status of the population. *Estrato I* means the lowest level, ie poverty, and *estrato VI* represents the highest level, ie rich citizens. According to “*estratos*“ are determined fees for public services in the form of contributions from curators and focus of urban social programs. Contributions represent a percentage relief from public utility charges (eg. *Estrato I* pays up to 50% less from the real price, *estrato II* 25% less and *estrato III* 15% less). Residents of the upper classes pay losses from the relief of lower classes. Social classes to some extent also affect property taxes, valuation of real estate, ect. (Websites IEU,2012). Classification into “*estratos*“ is governed by the applicable national legislation (Decreto 970 de 1991, Decreto 990 de 1992 and Decreto

2220 de 1993) . Municipalities and cities classify residents into „*estratos*“ according to the methodology issued by the National Planning Department (Mapa e información de estratos en Bogotá,2012).

Bogotá city is administratively divided into 20 parts (Figure 2), 19 parts is urbanized (Figure 3). These urbanized parts are: Usaquén, Chapinero, Santa Fé, San Cristóbal, Usme, Tunjuelito, Bosa, Kennedy, Fontibón, Engativá, Suba, Barrios Unidos, Teusaquillo, Los Mártires, Antonio Nariño, Puente Aranda, Candelaria, Rafael Uribe Uribe, Ciudad Bolívar). Only one fully rural part is Sumapaz (Pliego 001 de 2011). More than half of Sumapaz is national park and rest of the area is agricultural. Sumapaz lies in the South and belongs among poor areas (Figure 4).

2.2 Ecological problems of the city

The city of Bogotá is located in the plateau, in the location of formed swamps and wetlands. The city is squeezed between the alpin massifs, which limit an area where urban constuctions can be realized. The climate in the area of Bogotá D.C. has a character of temperate zone, but with torrential tropical rains, which carry risks of erosion, landslides and floods (Svetdnes,2010, Figures 14,78).

Environmental problems are caused by overpopulation and by specific natural and social conditions. Nature in Bogotá D.C. is in many ways unique, but it is often destroyed by construction of houses without planning permission (Figure 26). In these houses people live in substandard sanitary conditions, often without potable water, sewerage, ect.

One of the greatest environmental problems of the city is heavy pollution of surface water (Figures 22,30), Bogotá river is black, stinking sewer and in some places with a white foam on the surface (Figures 23,25,27). Based on many researches Bogotá river is without aquatic life (CAR,2012).

Everyday life of the city of millions citizens cause production of large quantities of solid waste. Storage of solid waste in the landfill demands use of land. Solid waste is brought to the walley, which during the operation of the landfill has completely disappeared. The amount of waste annually rise up and the landfil is constantly expanding. Environmental problem of landfill is a soil erosion (Figures 76,77,78) and landfill gas (LFG), which contain a substantial amount of methane and carbon dioxide. This gas always originate at municipal waste landfills. The highest production of LFG is between 5 and 13 years after

the deposit of waste, but the gas is generating for 20 to 30 years. LFG, if is not pumped from the landfill, uniformly migrates through layers of deposited waste in the landfill in all directions. Thereby threaten a danger of creating an explosive mixture with air, even in a distance of several hundred meters from the landfill body (Simerský, 2012). Pumping of the gas is not only necessary because of the danger of explosion of accumulated gas but also for the protection of the environment, mainly prevention of pollution by greenhouse gases, which damage the protective layer of the atmosphere. Methane emissions are limited by combustion of LFG, which generate water vapor and carbon dioxide. (Simerský, 2012). LFG also reduce the oxygen concentration in the upper layer of the landfill cover, which prevents the implementation of biologic recultivation (Websites Biomass technology,2012).

2.3 Agriculture in the neighborhood of Bogotá city

In Bogotá D.C. is one fully agriculture district and seven urban districts with agricultural activities. These districts are Ciudad Bolívar, Usme, San Cristobal, Santa Fé, Chapinero, Usaquén and Suba. Agricultural zones has a low level of public services and are located in mountainous areas, in some parts reaching over 3000 metres AMSL. Only district Suba is a lowland. Agricultural land is under the expansion of rural areas mainly in Usme and Ciudad Bolívar districts through still emerging slums. Rural areas cover land of 122.689 ha in Bogotá D.C. which represent 76,8% but only 31.507 ha (25,7%) is agriculturally used. Rest 91.182 ha (74,3%) are protected or abandoned areas. The largest and almost only economic activity in rural areas is a farming. When 84,9% of agricultural land is used for pastures, represented mainly by cattle for milk, goats horses. Only 15,1% of land is used for cultivation of crops. Potatoes are widely cultivated (64%) following by peas (23%), beans, corn, fruit, onion and other vegetable (Websites Alcaldía Mayor de Bogotá, 2012).

Bogotá river forms a west boundary of Bogotá D.C. and region Cundinamarca. This neighborhood of Bogotá D.C. is predominantly agricultural zone with pasturage and cultivation of crops and ornamental flowers, such as roses, orchid, callas and other flowers for national use and international export. This area includes “*La Ramada*” irrigation district with intensive cultivation of crops and fruit. The composition of crops cultivated in this part of Cundinamarca region is identical to composition of cultivation in Bogotá D.C. (Websites Alcaldía Mayor de Bogotá, 2012).

2.4 Bogotá river

Bogotá river drains an area of 5.859 km² and measures 365 km. Bogotá river rises 3500 metres AMSL in the Paramo de Gacheneque in the region of Cundinamarca, northeast of Bogotá D.C. and flows into Magdalena River 300 metres AMSL in the town of Girardot in the region of Cundinamarca (Figure 20) The area of the river basin is complex combination which mixes urban, industrial, power generation, agribusiness with agriculture irrigation. The water quality of Bogotá river is characterized by a high degree of pollution (Figures 22,23) which can be seen all the way. Despite, a recognized feature of the Bogotá river basin, especially in the region of Bogotá D.C., are the extensive and important wetlands (Figures 12,15,16). These areas have been historically important as habitats for many species, for its recreational potential and more for their potential to act as an integral part of the regional strategy for management of water quality. As recently as 1950, there were about 50.000 hectares of wetlands included in the Bogotá river system. At present, these areas have been reduced to less than 1000 hectares. All wetlands have the potential to serve different purpose and are recognized by various NGOs active in the area. Besides economic, social and environmental importance of the watershed, it is important to recognize the significant risk that cause recurrent flooding in the area. The combination of heavy rainfall, high water tables and limited runoff in the Bogotá river basin means that many part of the basin are subjected repeated strong flooding. These floods exacerbate the problems of high water tables in many parts of the basin near Bogotá city and cause widespread damage and affecting livelihoods structures. The current level of flood protection is based on a designed standard for flows with a return period of 25 years. The new works for flood control will be developed with a design suitable for flows with a return period of 100 years (Documento del Banco Mundial,2010). The average flow of the Bogotá river during dry season before entering Bogotá city is 12m³/s and the average flow of the river after Bogotá city is 36 m³/s (Documento Conpes 3631,2009).

2.4.1 River basin sectors

Basin of Bogotá river is divided into 3 sectors. The 1stsector „*Cuenca Alta*“ is located at the north of the Capital District. In this sector Bogotá river receives wastewater from 21 municipalities with a urban population of around 600.000 habitants and contribution of 360.000 t of annual sediment mainly from the basin of the Checua river flowing into the

Bogotá river. In this sector the impact of the river pollution generates and impairs quality of soil and crops under the irrigation. Pollution of the river starts seriously affect health of the inhabitants of the regions through river passes (Memoria general programa de saneamiento Río Bogotá,2011).

The 2nd sector „*Cuenca Media*“ of basin has approximately 90 kilometres of the river length and receives wastewater directly from Bogotá D.C. In this region Bogotá river gets daily about 300.000 tons of organic load coming from parallel rivers Torca, Salitre (Figure 46), Fucha and Tunjuelito which flows through the city of Bogotá D.C. 50% of the pollution is from the industry and Bogotá river is very polluted in this region (Memoria general programa de saneamiento Río Bogotá,2011). The land use on the left bank of the middle basin of Bogotá river (basically Bogotá D.C.) is predominantly urban and includes residential, commercial, industrial, recreational areas and some illegal settlements in the river bank area. The right bank is predominantly rural with irrigation district La Ramada, where polluted water from Bogotá river is intensively used. While Bogotá river itself does not flow through the city of Bogotá, many of the tributaries flowing into it from the city are heavily contaminated as a result of discharges from densely populated urban areas. Coming out of Bogotá D.C., the river descends steeply 2000 meters in a short way made up of rapids into the valley of the Magdalena River. In this part of basin Company Emgesa has built a hydroelectric power plant of two tracks (1124 MW of installed capacity) downstream from Bogotá to take advantage of the flow and the gradient of the river. The other track of the power station is the reservoir Muña, of 853 hectares, which is also heavily polluted and produces heavy odor (Documento del Banco Mundial,2010). The area of rapids is terminated by 132m high spectacular waterfalls called Salto de Tequendama (Figure 19) but unfortunately this waterfall has been incorporated into the hydroelectric scheme, so the water cannot flow consistently year round and often is dry.

The 3rd sector „*Cuenca Baja*“ has a longitude of 110 km and terminates in the Magdalena river, one of the main rivers in the country. The river is used for power generation and irrigation in agriculture. The river is very polluted and seriously affects human health of the inhabitants of the region (Memoria general programa de saneamiento Río Bogotá,2011).

In summary pollution of the Bogotá river starts in the upper part of the river and affect all habitants along the river basin. The pollution of the surfacewater cause intensive use of

groundwater and the progressive depletion of eutrophication and consequent destruction of the wetlands and limits recreation areas for the population (Memoria general programa de saneamiento Río Bogotá,2011).

2.4.2 Character and monitoring of pollution

For many years Bogotá river was used as an open sewer for large part of the city of Bogotá. Since 1950, the rapid urban development has impact on destruction of wetlands caused by growth of low-income communities along the river which are susceptible to flooding (Documento del Banco Mundial,2010). The main river quality problems are associated with high organic load from households sewage discharge from municipalities in the basin. Other big source of pollution is industrial contribution equivalent to an additional 5 million inhabitants (Memoria general programa de saneamiento Río Bogotá,2011). The main source of pollution are inhabitants of the Bogotá D.C - 6.778.691 inhabitants of Bogotá D.C. (Pliego 001 de 2011) and about 10.5 people with suburbs. People discharge all their sewage water into the river Bogotá through its three main tributaries: Salitre, Tunjuelito and Fucha (Documento del Banco Mundial,2010).

In the year 1961 was by the law 3 of 1961 (Ley 3 de 1961) established Regional Autonomous Corporation of Cundinamarca (CAR). CAR has issued law agreement (Acuerdo 43 de 2006) which set the water quality classification for the Bogotá river basin and the objective of the river decontamination which has to be achieved no later than 2020. The water quality classification is divided into five levels depending on the type and quantity of the pollutants (Acuerdo 43 de 2006). The water quality classification was extended of two more levels for internal uses and project planning (Adecuacion,CAR,2011).

The Bogotá river basin exhibits varying degrees of the water quality degradation (Figure 51) depending on where and when samples are taken. The degree of pollution depends on the season levels of rainfall. Overall, water quality increasingly deteriorates as the river moves from the upper catchment towards the middle basin, densely populated, and to the lower basin. Throughout the length of the Bogotá river, the data collected through monitoring activities of water quality indicate a high organic content and large amounts of the nutrients, low level of dissolved oxygen and high level of waterborn pathogens. The level of pollution increases as the river approaches and crosses the region of Bogotá city,

situated in the 2nd sector of basin (Documento del Banco Mundial,2010). Bogotá River and its tributaries have received domestic wastewater containing organic and inorganic minerals, heavy metals, pesticides, fungicides, herbicides and sediments in amounts that greatly exceed the dilution capacity and self-purification of the river. Residents of the banks of the river channel are affected by serious health risks and aesthetic effects resulting from water pollution. Bad odor and aesthetic quality of the river is considerable in many places of Bogotá D.C.

2.5 Wastewater treatment system

Separate legislations refer at the wastewater treatment in Colombia. These legislations are issued at the national and regional level. However, their compliance is not consistently monitored or controlled. The result of inadequate control of compliance of legislative, caused the unsatisfactory state of the environment in Bogotá city. This is the most evident on the pollution of the Bogotá river, where is erased a presence of aquatic life. In recent years is a significant increase of the interest of the city government to improve the situation of the contamination of the river. The main initiator is CAR (Herrera Herrera,2011). Treatment of industrial wastewater is regulated by decree (Decreto 3930 de 2010), which imposes duty to any industry clean wastewater at its own expenses before release into the environment. Permission for industrial activities is issued after prove of confirmation that the manufacturer built a WWTP. Confirmation has validity for ten years, after this time, company must apply for new certificate which evaluates the quality of treated wastewater (Decreto 4728 de 2010). CAR inspects the quality of treated wastewater. In case of exceeding the pollution limits, CAR has a statutory power to impose fines (Herrera Herrera,2011, Acuerdo 43 de 2006). Rain water flows directly into surface waters. Rain water is discharged directly or through a short canal system to the tributaries of Bogotá river, which flows through the city (Figures 35,36,37). This has resulted in massive pollution of the river Bogotá by municipal solid waste (Figures 30,43,66,67), which are washed out into the river during rain (Herrera Herrera,2011). Sewer system of domestic wastewater is in Bogotá city inadequate. In the north of the city is built up insufficient amount of sewers. The main truck of sewage system are collectors (Figure 50). These colectors collect water from sewers and bring into the Salitre WWTP (Figure 48), which is the only one WWTP in the Bogotá D.C. The rest of the sewers has a wrong conection to the system and discharge a big amount of wastewater directly into the rain water system,

which is river Salitre (Figure 46) and its tributaries and all wetlands around. The biggest problem of wrong connection is within illegal urban construction. In the rest of the city, as is the basin of the river Fucha and Tunjuelito, is a lack of sewer system and wastewater is discharged directly into environment. Direct discharging and wrong connection of sewers cause high pollution and serious health risk in the basin of Bogotá river (Guía conceptual sobre la Ptar Salitre,2012).

2.5.1 WWTP Salitre

WWTP Salitre was built in the year 1997 after many studies and projections which are dated since 1906 (Memoria general programa de saneamiento Río Bogotá,2011). Salitre WWTP is the only one municipal sewage plant operating in Bogotá city located north of the city on the one of tributaries of Bogotá river, called Salitre (Figure 47). Bogotá city discharges $24\text{m}^3/\text{s}$ of sewage water of which only 20% is primary treated in Salitre WWTP (Documento Conpes 3631,2009). Salitre WWTP has a capacity of $4\text{m}^3/\text{s}$ (Memoria general programa de saneamiento Río Bogotá,2011) and cleans sewage water of north part of Bogotá city with a small amount of water from river Salitre (Herrera Herrera,2011). WWTP Salitre is connected to three collectors of which the one around the river Salitre is under the construction (Adecuacion, CAR,2011).

In the WWTP Salitre is used only primary treatment of domestic wastewater which is divided into three stages. In the first stage is the wastewater treated by big and small screens, which separate a solid waste as bottles, papers, wood and other floating material in the wastewater. WWTP catches 60t per month of solid waste (Guía conceptual sobre la Ptar Salitre,2012). Second stage is a removal of insoluble solids such as sands and materials such as fat and foam. The water is treated 7 up to 12 minute and chemicals are added into the water to accelerate sedimentation. The third stage is sedimentation of organic matter, bacteria, parasites and other sedimentary solids. WWTP Salitre has eight sedimentation tanks where are added other chemicals to accelerate the process of sedimentation. After the sedimentation the water is discharged into the Bogotá river (Guía conceptual sobre la Ptar Salitre,2012).

Sediments are moved into two tanks of thickening. The water from this process is moved back in the beginning of the all process of cleaning and the thick sediments are moved into three digestion tanks, where the sediment is treated between 17 upto 22 days in the

temperature of 35°C. In this process is accumulated biogas which is used for heating of the digestion tanks and the rest of biogas is combusted. The digestate is dried and used as fertilizer and the water is pumped back in the beginning of the cleaning process. WWTP produced 4950 t of digestate per month (Guía conceptual sobre la Ptar Salitre,2012).

2.5.2 Projects in the field of wastewater treatment

The intolerable situation of the surface water quality and high frequency of floods mainly in the region of Bogotá D.C. has forced mayor of Bogotá city and other governmental institutions to find a solution how to clean up the river pollution. The main reason for this decision comes from the high health risks caused by the river pollution for habitants of river banks, disappearing flora and fauna of wetlands and huge contribution of pollutants on agricultural yield through the irrigation from Bogotá river. Various regulations established at the national level are applied on the urgency of the decontamination of Bogotá river. The two mains are: Article 79 of the Colombian constitution which says: *„...all people are entitled to enjoy a healthy environment ... it is the duty of the state to protect the diversity and integrity of environment“* and law 99 of 1993 (table 1, p. 36). There are two projects in the field of wastewater treatment with main goal to achieve the presence of aquatic life in the Bogotá river (Memoria general programa de saneamiento Río Bogotá,2011).

2.5.3 Bogotá river sanitation project

Bogotá river sanitation is very important project situated into the *„cuenca media“* where the river forms a boundary of Bogotá city with a stretch of about 68 km. This sanitation project has two main purposes. The first goal of the project is to improve the quality of Bogotá river and reduce the flood risk, the second goal is to build up a multifunctional areas along the river basin of Bogotá D.C. (Documento Conpes 3631,2009).

This project will develop flood control with a design suitable for flows with a return period of 100 years by reconstruction of restoring meandres and wetlands. Further, projects consider landscape design and multifunctional areas along the river. The project will generate 8 multifunctional areas with an approximate area of 175 hectares. The land of this areas will be recovered and intended for uses of protection and ecological conservation, flood zones and areas of public entertainment. The project will return *„life“* on the river banks by construction of parks, playgrounds, rest zones and other entertainment zones.

Cycleway will be built all along the river basin of Bogotá D.C.. Project expects increase of living standards in neighborhoods of Bogotá river (Documento Conpes 3631,2009).

Work plan considers a deepening of the riverbed and expansion of the flood zone with new embankments protecting the city and agricultural land against floods. This will cause a massive destruction of illegal neighborhoods along the river basin and relocation of approximately one hundred houses and two hundreds of families. The government will buy the land from the owners which is included to the river sanitation plan. Furthermore, this project counts with a recuperation of the rain water canals and river canals in Bogotá city (Documento del Banco Mundial,2010).

2.5.4 Project of the wastewater in Bogotá city

Because of the insufficient wastewater treatment in Bogotá city, lack of sewage system and many realized independent studies the government of Colombia decided to support a huge project to build up a proper wastewater treatment system in Bogotá city. This project has many steps of realization to create a proper sewage and wastewater treatment system. Steps of this project are realized independently to each other (Documento del Banco Mundial,2010).

The first plan is an extension of WWTP Salitre. WWTP Salitre has a capacity only of about $4\text{m}^3/\text{s}$ and it is not connected to proper sewage system. In this plan the WWTP Salitre will be extended of other $4\text{m}^3/\text{s}$ to total capacity of about $8\text{m}^3/\text{s}$ of wastewater. During this reconstruction will be add a conventional secondary treatment (Documento Conpes 3631,2009). The secondary treatment is a conventional biological process which uses aerobic bacteria that consume an organic matter presented in the waste water. In this process is very important aeration to achieve a high level of dissolved oxygen (Guía conceptual sobre la Ptar Salitre,2012). The second plan is a construction of the new WWTP called Canoa. This WWTP will be located out of the Bogotá in the south and treat wastewater from south of Bogotá city and one of the biggest suburbs Soacha. In this WWTP will be implemented new technologies for chemical and biological treatment with a capacity of about $16\text{m}^3/\text{s}$. WWTP will be built in three stages. First stage involve primary treatment. Once primary treatment will be operating, starts a construction of secondary stage, which involve conventional biological process. Third and last stage will be a

construction of third treatment, which removes nitrogen and phosphorus. In the project of WWTP Canoa is not considered any use of biogas (Adecuacion,CAR,2011).

Next plans involve construction of five huge collectors of wastewater. These collectors collect sewages and bring the wastewater into WWTPs. Collectors are built mainly around the river canals in the city to separate sewage water from the river water and rain water. By this project city wants to stop direct discharging of wastewater into rivers and starts the process of cleaning up the city rivers. WWTP Salitre is connected to three collectors of which one around the river Salitre is under the construction (Documento Conpes 3631,2009). The project involve one collector in the north of the city with a longitude about 4.230 m and pipe diametre about 1,8 m, which will collect the waste water between rivers Fucha and Salitre. This collector is nowadays under the construction. In the south of the city are projected four huge collectors. One collector will be located around the river Fucha, second collector will be located around the river Tunjuelito, third will connect all system with WWTP Canoa. This collector has a longitude about 8 km and pipe diametre about 4,25 m. Fourth collector will connect system with Soacha. The connection between collectors of river Fucha and Tunjuelito belongs to the project „collector river Fucha“ and has a longitude about 9,8 km and pipe diametre about 3,75 m (Figure 50). Nowadays it is under the construction (Principales obras del megaproyecto de Saneamiento del Río Bogotá,2012).

By these projects is expected coverage of capacity of sewage water produced in Bogotá city and bring it to the WWTPs for its decontamination. Separation of the rain water and wastewater will contribute on the entire decontamination of Bogotá river (Documento del Banco Mundial,2010).

2.6 Waste management

Separate legislations refer the waste management in Colombia. This legislation is issued at the national and regional level, therefe the situation is in each area quite different. Waste management in Bogotá city is included in the public services provided by the municipality of Bogotá, which ensure collection and landfilling of municipal waste, green maintenance and care of cleanliness of the city. Possibilities of waste sorting and subsequent recycling exist in the region of Bogotá D.C., but are not yet quite common. The waste sorting currently works more at the level of the collection of secondary raw materials, which is

beneficial to collect and deliver in the places where materials are bought up. This method of waste management means for many people source of income.

Until 1993, was in Bogotá D.C operating the only one state-owned company „*Empresa de Servicios Públicos Distrital – EDIS*“, which was canceled due to financial problems. Subsequently government of Bogotá D.C. issued a public tender, on the basis of which was in October 1994 signed a nine-year’s contract for the period 1994 - 2003 with four companies, which provide maintenance of various parts of the city of Bogotá. The city was divided into seven zones, which included 1.522.252 houses. Upon expiration of this contract was issued a new tender, seven – year’s contract was signed with four companies for the period of time from 13th of March 2003 to 31st of June 2010. Bogotá city was divided for this purpose into six parts - *Las Áreas de Servicio Exclusivo - ASE* with a total amount of 1.760.210 houses (Pliego 001 de 2011).

In December 2011, government of Bogotá D.C issued a new tender (Pliego de condiciones licitación pública, 2011), a nine - year’s contract for public services for 30.736 hectares of urbanized parts of the city of 6.778.691 citizens (according to data from 2005). These urban areas are divided into six zones in total. The tender will select three companies of which each one cannot take care of more that two such zones at once. The tender was annulled by court decision (Corte Constitucional, Auto No 275 de 2011) and new tender will be issued. The tender was canceled because the court upheld the objections of those who criticized the insufficient security of waste sorting and recycling. The objections were not motivated by protection of the environment, but by fear of the loss of profit from the collection of secondary raw materials, which are bought up. Existing contracts are renewed on the basis of Resolution 2012 (Resolución de 2012), by which is declared in Bogotá D.C. a state of urgency to ensure continuous hygienic needs of the city.

2.6.1 Waste sorting and recycling

Start of recycling is dated in Bogotá D.C. between years 1940 and 1950 due to the large immigration of 3.6 million people into big cities. This immigration was caused by Colombia’s inner conflict in the countryside. This high immigration caused a high level of unemployment and people started to work in illegal activities and informal economies such as waste sorting and recycling. Nowadays, 22.000 of poor people works in informal waste sorting in Bogotá D.C. and it represents their main or only one economic activity.

Into the waste sorting are very often involved all family members including small children. In average 3000 people are aged between 15 and 18 years, 19% are illiterate and 81% reaches the basic education of the Colombian level. Only 11% is formally organized in groups and recycling companies (Corredor,2010).

In the year 2006 was established Special Administrative Unit of Public Service (UAESP) in Bogotá D.C. UAESP created a formal waste sorting center La Alqueria for right utilization of sorted waste for the reason of high volume of solid waste exported to landfill Doña Juana (Corredor,2010). La Alqueria is named after its location which is the neighborhood of Alqueria in the southwest of Bogotá city. Sorted waste is received in the center, classified and sold to the recycling companies (Figures 62,63). La Alqueria has 55 permanent employees and organizes trainings and educational programs for around 150 people who want to know about waste sorting and recycling process and companies (La Alquería,2012). Truck of La Alqueria has a special route for each day and collects sorted waste of 15 rural districts of Bogotá D.C. (Figures 61). Nevertheless, this route covers only 33% of potentially recyclable waste produced on these districts. La Alqueria receives in average about 10 t of sorted waste daily (Centro de Reciclaje La Alquería,2012)

Most of the waste sorting is made by the informal way which contributes to pollution of the environment. People collect recyclable waste from rubbish bags which are left prepared to be picked up by a dustman in front of houses. Often those people pick up all rubbish bags to sort the waste later on the river banks, edges of wetlands, under bridges, green zones or on the empty streets. Those people collect construction waste, cardboard, paper, plastic, glass and metal and the rest of non-recyclable waste is left on the place and causes pollution. The sorted material is transported by “zorras” - cars pulled by horse (Figure 64) - or “zorros” - cars pulled by a human - to collectors who store and classify the material by type. Often the odor and some diseases are found in sectors where these houses are located. This kind of informal collectors is not permitted by a district's law. Nevertheless, there are many of them as there is not substantial control. These collectors sell potentially recyclable materials to middlemen, retailers or recycling companies (Corredor,2010).

The most sorted materials are plastic, paper, paperboard, glass, metal and clothes. The technological and electric waste is not sorted and goes directly to the landfill. (La Alquería,2012).

2.6.2 Projects in the field of waste collecting

Under the Resolution 2397 of 2011 (Resolución 2397 de 2011) of the Department of Environment of Bogotá D.C., the recycled construction waste must be used in the new constructions since year 2012. In the private sectors must to be 5% of used materials coming from recycled construction waste and in the public construction 10%. This percentage will grow up of 5% every year in both sectors until it reaches 25%.

In the end of the year 2011 assembly of the city decided to support UAESP and process of waste collecting and recycling. On 14th of January 2012 newspapers El Tiempo published a new program of the mayor of Bogotá D.C. with coordination of UAESP, called „zero basura“ (zero waste). This program is focused on classifying the waste from the source because there is found a main problem in the recycling chain. The objective of the program will be achieved by three main activities. First activity will be a massive education campaign in the public and private schools with capacitation of 1.600.000 students how to classify the waste. Another campaign will be presented as official visits of houses in residential parts of the city. In the second part, mayor expects creation of tax reduction of public services for those who will recycle and the third activity would be a creation of penalties for those who will not recycle. Furthermore, the program considers that collection of recyclable waste could be made by static boxes and for each type of recyclable material would be defined a specific color (Figure 60).

2.6.3 Municipal landfill Doña Juana

In 1988, the city of Bogotá established municipal waste landfill Doña Juana (Figures 69,70). Landfill is located at the altitude of 2.715 – 2.800 metres AMSL and cover area of 592 hectares (Rodrigues,2011) where, based on data from 2010, is stored 185.910 tons of solid waste per month (Websites CGR,2012). This amount represents 15% of all waste generated at the national level (Guerrero,2011). Daily about 800 trucks (of capacity about eight tones) bring in average 7.000 tones of municipal waste to the landfill (Websites CGR,2012). The river Tunjuelito flows through the area of the landfill, into which is discharged treated wastewater from the landfill. This river enters the city of Bogotá and flows through the southern urbanized parts of the city.

The operation of the landfill is ensured by the company CGR Doña Juana (CGR), which ensures technical support and operation of landfill and also organizes training of the population, excursions at the landfill and other activities. (Guerrero,2011).

2.6.3.1 History of the landfill Doña Juana

The municipal landfill Doña Juana is located in the southeastern part of Bogotá city, near the main communication Boyacá. Establishment of the landfill dates back to the 1st of November 1988. Initially, the waste was formed into five metres high mounds, without any secure against leaks and without any wastewater treatment or drainage of the water coming out of the landfill. At the time the landfill operation occupied area of 14 hectares and disposed waste was covered only with plastic sheeting (Figure 71). This technical situation cause odors, seepage of rainwater into the waste and the waste was an accessible source of food for vectors (Guerrero,2011).

On 27th of September 1997 occurred at the landfill to the massive explosion of accumulated LFG and a significant amount of polluted wastewater was released into the environment (Figure 68). With this explosion was 3.000.000 tones of solid waste ejected into the environment, what resulted, inter alia, damming the river bed of Tunjuelito with 500.000 tones of municipal solid waste. In the capital was immediately declared a state of emergency. After this incident was built sewage treatment plant and was implemented process of landfill degassing to prevent future explosions (Websites CGR,2012).

CGR is now also focused on social assistance in areas adjacent to the landfill. The company tries to improve the living conditions of people living near landfill sites. The company accept responsibility of the impact of operating the landfill on surrounding residents. The landfill signifies income for many people (Triana Delgado,2011).

It is interesting that: CGR Doña Juana has established a program called „man´s best friend“ for adoption of dogs and cats which enter the landfill to find a food (Figures 79,80,81). Dogs were hitherto regarded as vectors and were captured and killed. CGR states that dogs and cats are pets and must be protected. CGR wants to by this program give to these animals another chance and better life (Websites CGR,2012).

Currently, management of CGR nor government of the city do not consider a construction of municipal waste incineration, in duscussion is a modernization of the sewage treatment plant, due to the finding of heavy metals in the discharged water. After closure of the

landfill in the future will be established an extensive natural park of planned planting of 43.000 trees at least (Rodrigues,2011).

2.6.3.2 Structure of the landfill

The landfill is divided into 13 technical zones, which are further divided into fields. Currently two zones are in operation, „pathogens zone“ and „zone of optimization“. In the landfill is not sorted or recycled any waste. The landfill Doña Juana has projected life of ten years until 2021 (Rodrigues,2011).

The structure of the landfill is as follows:

- Zone I is the historically first part of operating of the landfill, which was in the operation from September 1988 until September 1993. This zone is closed, recultivated and transferred into a meadow.
- Zone I, field VII was in the operation from September 1993 until September 1995. This part is currently closed and under the recultivation.
- Zone „Mansion“ was in the operation from February until October of 1995, currently closed and under the recultivation.
- Zone II was in the operation from October 1995 until September 1997. A massive explosion of LFG took place in this zone in 1997. Currently closed.
- Zone III is located at the lower part of the landfill, near Boyacá communication and large cemetery cerafín. Currently closed.
- Zone IV is currently closed and under the recultivation. This zone was under the operation between September of 1997 and January of 1999.
- In the Zone V is situated WWTP of wastewater from the landfill. Decontaminated water is discharged to the river Tunjuelito, before entering the city of Bogotá.
- Zone VI is prepared as an emergency capacity in exceptional circumstances.
- Zone VII was in the operation from March of 2000 until November 2002. This zone is currently closed and prepared for recultivation (Websites CGR,2012).
- Zone of hospital waste is operating under the technical name „Zone of pathogens“. This zone was in the operation between years 1998 and 2004, then the zone was

temporarily closed until the decision of extension. Currently operating with planned capacity until 2015 (Rodrigues,2011).

- Biosolids zone was designed to receive all biosolids from the treatment of WWTP Salitre until the year 2007. This zone is currently decommissioned.
- Zone VIII was operating from April 2002 to September 2010 and currently is decommissioned.
- Zone of optimization was inaugurated on July 1st of 2011 since when is operating. This zone is dividend in two fields of operation. The field I is in operation and the field II is being constructed for more disposal of waste from the capital (Websites CGR,2012).

2.6.3.3 Technical security of the landfill Doña Juana

Before filling by waste, the zone is dug up and the bottom is prepared by modern technologies against seepage of wastewater, such us geomembranes and drainage network, which will drain off wastewater (Figure 73,75) from the landfill body (Rodrigues,2011). Gas wells and drainage system is set up. The waste is then bring and put in layers, which are always covered with soil and geotextiles (Guerrero,2011).

Stored waste is ultimately covered to prevent their expansion into the neighborhood and not become a source of food for vectors. The landfill is protected against rain water, which can be significant in rainy season, by dense drainage network so that rain water run off quickly and without contact with waste and leakage into the landfill body. Ground water is collected and ran off from the landfill body quickly to minimalized leachate from the waste and subsequently treated in WWTP located in Zone V. Collecting of LFG is ensured (Figure 74). It is ensured that the landfill have the least impact on the environment (Websites CGR,2012).

LFG is not pumped from all area of landfill. Collecting of LFG is implemented in zone VIII and part of the zone II. LFG is collected by gas wells, which are evenly spaced and connected to the piping. Production of LFG in the landfill is 14.000 m³/h, of which 50% creates methan. The gas contaminated, so at the end of the main piping is installed filter (Rodrigues,2011). LFG is disposed by incineration. According to communications with director of the landfill operation (Guerrero,2011) is planned use of LFG for energy supply of the landfill. The drilling of gas wells in already closed areas is not considered.

All waste water is drained from the landfill into the tailings and then to WWTP (Websites CGR,2012). Physical, chemical and biological pollution is controlled in the water. The WWTP strictly monitors and cleans 22 kinds of heavy metals and other toxic substances (Rodrigues,2011). However, according to CAR survey conducted in November 2011 and published in Colombian TV was found considerable amounts of heavy metals and other toxic substances that are discharged into the river Tunjuelito after the process of decontamination (CAR,2011). The river Tunjuelito flows into Bogotá river and then into the river Magdalena. Municipal landfill Doña Juana discharged 21 l/s of treated wastewater into the river Tunjuelito (CAR,2011).

The landfill is covered with a special cap containing soil to prevent the spread of flies and odor. The cap also compresses the waste. The landfill in this way reduces the amount of insect vectors, mainly flies. Before flies nests under perforated plastic films, which were previously used. Nowadays, the amount of flies and odor is significantly reduced due to new technological processes of covering the waste (Websites CGR,2012). The author can attest reduced odor and amount of flies by personal visit of the landfill.

The entire area of the landfill is not secured by fence against intrusion of human or animals (Figure 72). The fence is built in the length of 7 km and only in areas adjacent to slums near by the landfill. Residents of these slums very often steal this fence around the landfill which allow access into the area of the landfill for domestic animals. People and domestic animals very often become vectors by themselves (Guerrero,2012).

2.6.3.4 Operation of the landfill

The landfill is in operation 24 hours per day and 800 vehicles bringing municipal waste enter the landfill during the day. Once the vehicle enters the landfill is weighed and checked. The vehicle is directed depending on the type of waste to the appropriate zone. Each vehicle spends at area of the landfill in average 35 minutes. The soil erosion and landslides of entire slopes occasionally occur on the recultivated zones due to recurring tropical rainfalls. These defects of landslides are promptly fixed and additionally secured (Rodrigues,2011).

2.7 Environmental legislation of Colombia

Statutory regulations of Colombia, which are related to the topic of the thesis, were studied. Laws of Colombia are publicly accessible, also via internet. All legislation is in Spanish. According to the decentralized governance of the country the legislation is also issued at regional level. Laws (*Ley*) are denoted by number and year of publication, as well as implementing regulations of these laws - decree (*Decreto*). Publicly accessible are also Agreements (*Acuerdo*) and Resolution (*Resolución*) issued by state organizations and which are binding.

Environmental protection is enshrined in the Constitution of 1991 (La Constitución Política, las Leyes de la República de Colombia), where is determined the state's duty to protect environmental diversity and integrity, preserve areas of special ecological significance and promote environmental education and awareness to ensure the right of all people to a healthy environment and allow the use of natural resources in accordance with the practice of sustainable development, so that these resources were preserved for future generations. In the Constitution is also formulated right of the State to monitor compliance with these principles, make sanction and to claim damages.

In 1993, the Ministry of Environment (Ministerio del Medio Ambiente). was established by Law 99 of 1993 (Ley 99 de 1993). The Colombian territorial self-governing corporations (CAR deC) have the responsibility for enforcing the laws and relevant regulations of environment, renewable natural resources and sustainable development.

The Law 2811 of 1974 (Ley 2811 de 1974) is an important regulation, which includes a national code of natural resources for environmental protection purposes.

2.7.1 Wastewater treatment

The wastewater treatment covers a number of current legislation. The Law 142 of 1994 (Ley 142 de 1994) is one of the most important laws, by which were set up rules of the delivery of public services. Implementing regulation to this Law is Decree 1713 of 2002 (Decreto 1713 de 2002). Decree 4715 of 2010 (Decreto 4715 de 2010) sets up rules for the allocation of funds for the provision of subsidies for construction and maintenance of public water and sewer system.

2.7.2 The river Bogotá

The river Bogotá is a very significant river and some important laws and other documents are related to it, some of them are shown in next table:

Table 1. Legislation of Bogotá river

| Legislation named | Regarding |
|--|--|
| Law 9/1979 (Ley 9 de 1979, title I) | uses of water and liquid waste and other provisions |
| Law 2811/1974 (Ley 2811 de 1974) | national code of natural resources |
| Law 99/1993 (Ley 99 de 1993) | <p>Art.2 The Environment Ministry will lead the managing of the environment and renewable natural resources</p> <p>Art. 30 The Regional Autonomous Corporations will support the implementation of policies, plans, programs and projects on environment and renewable natural resources</p> <p>Art.31 parts 10 and 11 responsibility of the Regional Autonomous corporations, set in the area of their jurisdiction, the allowable discharge limits, transport or storage of substances, products, compounds or any other matter that may affect the environment or renewable natural resources and to prohibit, restrict or regulate the manufacture, distribution, use, of disposal or dumping substances that cause environmental degradation.</p> |
| Decree 3100/2003 (Decreto 3100 de 2003) | <p>Government regulated the remuneration rates for the direct use of water as a recipient of the dumping point and took other determinations</p> <p>Art 3. the competent environmental authorities charged by dumping the effluent charge made at specific water bodies in the area of jurisdiction</p> <p>Art. 6environmental authority must among other aspects establish quality objectives for water bodies according to their use in accordance with the Plans Water Resource Management</p> <p>Art 12 determined that for purposes of establishing the individual goal of reducing the pollutant load, users sewerage service providers subject to payment of the fee shall submit to the environmental authority, the Plan of Sanitation and Management of Dumping in accordance with the regulations</p> |
| Decree 3440/2004 (Decreto 3440 de 2004) | partially modified Decree 3100 of 2003 |
| Resolution 1433/2004 (Resolución 1433 de 2004) | Modification of Decree 3100 of 2003 in Article 12. Sanitation Plans and Management of Dumping – PSMV- Planes de Saneamiento y Manejo de Vertimientos-, constitute the set of programs, projects and activities, their timelines and investments needed to advance in sanitation and treatment of effluents, including collection, transportation, treatment, and disposal of wastewater discharged into public sewerage system, both sanitary and storm, which must be coordinated with the objectives and goals of quality and use to define the competent authority for the current segment or water body |

| | |
|--|---|
| Resolution 2145/2005 (Resolución 2145 de 2005) | Modification of Resolution 1433 of 2003 about terms of presentation the sanitation plans |
| Agreement 43/2006 (Acuerdo 43 de 2006) | By which sets the water quality objectives for the Bogotá River Basin to achieve in 2020 creates 5 water quality classes with different biochemical compositions established ranges through the river on the class must have each section |
| Decree 3930/2010 (Decreto 3930 de 2010) | By which is partially regulated by Title I of the Act 9 of 1979 as well as Title VI Chapter 11del-11del Part 11I-Book Decree - Law 2811 of 1974 in terms of water use and waste liquid and other provisions |

2.7.3 Waste management

Solid waste management is handled by a number of current legislation, laws, decrees, binding agreements and resolutions. This area, as well as wastewater treatment is covered by Law 142 of 1994 (Ley 142 de 1994), by which is laid down the delivery of public services. Implementing prescription for regulation under this law is a Decree 1713 of 2002. Resolution CRA 482 of 2009 (Resolución CRA 482 de 2009), which specifies methods for calculating discounts on charges for the use of public services hence from this law. Decree 1505 of 2003 (Decreto 1505 de 2003) changes a Decree 1713 of 2002 (Decreto 1713 de 2002) with regard to new plans for integrated solid waste treatment.

Law 632 of 2000 and 689 of 2011 are another important laws about maintenance of public areas and integrated system of solid waste management (Ley 632 de 2000, Ley 689 de 2001) and Decree 891 of 2002 (Decreto 891 de 2002), which change article 9 of Law 632 of 2000.

The master plan for solid waste management in the city of Bogotá was adopted by Decree 312 of 2006 (Decreto 312 de 2006), this Decree is amended by Decree 620 z roku 2007 (Decreto 620 de 2007). This Decree adds master plan for solid waste management in the city of Bogotá and lays down urban and architectural standards for the construction of infrastructure and system for storage of municipal solid waste in Bogotá.

The program for organic solid waste is subjected to the Agreement 344 of 2008 (Acuerdo 344 de 2008). Modes of price regulation for persons performing public services and the methodology for calculating rates for cleaning services of municipal waste lay down CRA (Resolución CRA - 351 de 2005).

2.7.3.1 Landfill Doña Juana

The landfill Doña Juana is subjected to the laws and documents which are listed in the following table:

Table 1. Legislation of landfill Dona Juana

| Legislation named | Regarding |
|--|--|
| Decree 190/2004 (Decreto 190 de 2004) | Recognizes the landfill Doña Juana as the current site for the disposal of solid waste from the city of Bogotá |
| Decree 312/2006 (Decreto 312 de 2006) | Determined to be used the soil as protection in the expansion of landfill Doña Juana additional 130 hectares Create 500 hectares as reserve for adecuation in the future of the Landfill Doña Juana |
| Decree 2474/2008 (Decreto 2474 de 2008) | About regulation of contracting with the government |
| Law 83/1993 (Ley 83 de 1993) | |
| Law 1150/2007 (Ley 1150 de 2007) | |
| Resolution CAR 2791/2008 (Resolución 2791 de 2008) | Fencing the area of Doña Juana landfill in an area the 7 km |
| Resolution of adjudication 662 (Resolución 662 de 2010) | Operating conditions and maintenance of the landfill in terms of solid waste and Leached |
| Contract 344/2010, with CGR, (Contrato 344 de 2010) | New contract to operate and maintained the landfill Doña Juana for period of 11 years. |

3 Objective of the Thesis

The objective of the diploma thesis is determine the current situation of the capital city of Colombia, Bogotá, in terms of waste management and wastewater treatment and their possible impacts. The objective of the thesis is also find out how management of Bogotá city protects the environment and whether citizens of Bogotá city are interested in these issues.

Determination of the state in the given environment was difficult, since it is the South American country with different living conditions that was the experience of the author of the thesis. It was necessary to respect the safety aspects of the movement in the field of local investigation for reasons of personal safety in places where is not recommended entry for foreigners due to high crime. Author made a contact with local residents, authorities and representatives of Bogotá city responsible for the studied area, indicated their willingness to cooperate and provide information.

The form of questionnaire was made to identify the relationship of the population of Bogotá city on issues of ecology, identification of their motivation and willingness to participate in any improvement of the current situation. The questionnaire contained questions designed to determine how residents dispose the waste, whether they sort the waste and use biologically degradable materials and chemicals. An important part of the questionnaire were questions of subjective proposals of residents for improvement of the waste management. These questions are an integral part of the evaluation of this study. The questionnaire was developed by the author himself and author personally addressed the people in public spaces and private building as well as personally visited several universities and high schools.

The introduction of the thesis summarizes the basic knowledge and natural conditions of Bogotá city and made a summary of factors that may affect the environment in and around the city. The diploma thesis deals with possibilities of improving the current situation.

4 Materials and methods

4.1 The used terminology and explanations of terms

| | |
|--------------------|--|
| Biogas | Biogas is produced by the anaerobic digestion or fermentation of biodegradable materials such as sewage, green waste, plant material etc. Biogas contains primarily methane (CH ₄) and carbon dioxide (CO ₂) (ČBA, 2012) |
| Decentralization | system of the allocation of competencies and powers to several organizational units, transfer of competence and powers of the institutions of higher to lower (Kraus, 2009, s.152) |
| Infrastructure | urbanism term - all utility facilities underground and over it (Kraus, 2009, s.348) |
| Regulation | State regulation of economic activity by the private sector (Kraus, 2009, s.688) |
| Respondent | interwieved (Kraus, 2009, s.696) |
| Resolucion | Fundamentals decision, in which are formulated requirements arising from the collective action (Kraus, 2009, s.699) |
| Landfill gas (LFG) | gas formed spontaneously by anaerobic decomposition in landfills. It is a mixture of methane and carbon dioxide (CH ₄ :CO ₂) and various admixtures (Souček, 2012) |
| Pathogen | Any disease-producing agent, especially virus, bacteria or other microorganism (Websites Dictionary.com,2012) |
| Slums | The poorest quarters with makeshift buildings in some big cities (Kraus, 2009, s.735) |
| Tendr | invitation to public competition, call for the most advantageous proposal for a contract (Kraus, 2009, s.793) |
| Trend | basic line of the observed phenomenon (Kraus, 2009, s.818) |
| Vector | transmitter, animal agent transmitting infectious disease (Kraus, 2009, s.847) |

4.2 Method of the own observation

Own observation was based on an exploration of the city. Observation was not restricted only to parts of the city, where it was safe to enter. When traveling by public transport, buses are passing with passengers through poor parts, so its possible to explore the city. Small buses „*busetas*“ (Figures 6,7,8) are the most suitable for this way of exploring, because these busses do not have stops and stop anywhere on their way on the request of passengers. This form of transport in Bogotá is very popular and with these buses is possible pass through a large part of the city. These „*busetas*“ can occasionally deviate from the original route during the traffic jam to avoid a stopping of the servise. Bus lines „*Transmilenio*“ (Figure 9) replaced the underground, these buses run only in the special corridors and stop only in designated stops. These buses are used mainly for quick movement in the city, not suitable for observing city life. This way of transport is unpopular (Figure 11) and criticized because for construction of corridors are cut down rare trees and some buildings are demolished. The „*Transmilenio*“ system capacity is insufficient to cover the number of passangers. Buses, stations and their surroundings are often crowned with people and built corridors for buses are overloaded and not enough to accommodate all traffic. In these cases, people are trapped in long queues of buses (Figure 10). Another criticism of „*Transmilenio*“ is due to the massive air pollution of Bogotá..

When riding „*busetas*“ it was observed that the behaviour and habits of the population are not the same everywhere. In some streets of the city is relative order and bins are placed on the streets. Elsewhere, however, is a visible mess, rubbish is strewed across the street and often smell is presented in such a place. This is a first warning for foreigners against entering such places.

The behavior of people on streets, schools, public spaces and offices can be seen that there is quite normal to throw unwanted things on the ground. Maintenance of public spaces are only contractually obligated to the companies, the citizens themselves do not support the purity. People almost do not even use own shopping bags, because the shopping centers and shops packed goods on the till automaticaly into many plastic bags (HDPE, LDPE) after a few pieces of goods.

During the stay in Bogotá author spoke with many people and discussed the topic of the thesis. According to personal communication with local people is obvious that people are

aware of the negative impact of non-ecological behaviour, however, is difficult for them to overcome their habits. They often do not have created suitable conditions to change their habits. The main problem that people perceive the most is the contamination of Bogotá river and other rivers and streams in the city. This topic is often subject of media reports, especially television and the internet.

On the request of the author of the thesis was made an excursion of Doña Juana landfill, at which was possible to see the operation of the landfill and operating and closed zones. For hygienic reasons (landfill workers have special vaccinations) the visit of the landfill took place only in a closed car from which was not allowed to leave, but the photodocumentation could be done.

4.3 The method of questioning residents

Behavior and relation of residents of Bogotá city to the environment was surveyed by opinion survey. The method of a dedicated questionnaire was used to determine the information from the surveyed population. The survey was distributed in 200 questionnaires (Annex 1), each contained 27 questions, of which three were open-ended and rest of questions were in a form of close-ended ordinal questions, where the respondent has more than two ordered options. The questionnaire was anonymous and was divided into two parts. The first part of the questionnaire was focused on the knowledge of residents about solid waste management in the city. The second part was focused on the knowledge about wastewater treatment system in the city. Original wording of the questionnaire in Spanish is showed in the Annex.

Presentation of the questionnaire was made of several administrative methods (Questionnaire administration modes). The first mode was Face-to-face questionnaire administration, where an interviewer presents the items orally. In this mode of questioning the author of the thesis addressed inhabitants of the city commonly on streets, in areas of public transport and shopping centers. Another researching was made by Paper-and-pencil questionnaire administration, where the items are presented on the paper. This mode ensured the author personally by visiting educational institutions such as universities and secondary schools, and discussed on the given topic with respondents.

The questionnaire was designed for two age categories: up to 30 years and 31 years and over. By this author wants to find out differences between older generation and students,

who now have the environment education in the curriculum and who are more commonly encountered with the theme of environmental protection connected with an increasing trend towards a healthy lifestyle. Older generations forming the second group of respondents consists primarily of working people and people with already established lifestyle. The purpose of the questionnaire was not a detailed examination of the opinion of different age groups.

The survey was conducted in the northern part of the city and northeastern part of the city center, where occurs most universities and institutions. Survey was not conducted in the southern and western part of the city, mainly due to the personal safety of the author. In the southern parts of the city live poorer inhabitants of Bogotá, where occur also slums, where is a high crime rate. Entry for foreigners into the southern parts of the city is not recommended, visit of southern parts of Bogotá can be for foreigners life-threatening.

According to the area in which research was conducted, we can suggest that most interviewed people belong to the group of educated citizens and therefore represent the population which belong from third to sixth caste grade of Colombia (Figure 5). The poorest and less educated citizens living in the south of the city may have a significant financial problems, so we can expect a lack of personal interest in protecting the environment, which is rather the secondary issue for them. However, we can not exactly say that people from south have a lack of interest on the environment. A large group of people who work and study in the north and city center, where the questionnaire was implemented, lives in southern parts of the city because of lower rents. Probably were not only interviewed residents who belong to the first and second caste grade of Colombia.

The author is aware that the data are identified by a certain degree of uncertainty due to the fact that the respondents do not come from all levels of the caste system of Colombia. The caste system is based on social and economic conditions and is not related to the environmental problems. It is certain that the willingness of poorer people to conform the questionnaire could be different than among those surveyed, but due to the security was not possible to come into contact with people living in the poorest parts of the city. The author is aware of this problem and during realization of the survey tried to address a widest amount of respondents occurring in place where survey was realized.

5 Results

It was found that Colombia publishes laws, agreements and resolutions, by which is controlled an operation of state administration and public services in the field of wastewater treatment and waste management. CAR controls the compliance of the legislation applicable to the subject of the thesis. The author discovered that the state of controlling the compliance of legislation regulations is not very effective. Perhaps it would be necessary to set appropriate control mechanism for environmental protection, e.g. establish such an institutions with power of inspection, which would be able to require correction of identified deficiencies and impose fines.

Companies providing public services have websites where currently inform about their activities. The media, especially television, provides information about the given topic of the environment. The author of the thesis met with helpfulness during a personal visit of offices and institutions, in addition, the author was also surprised by the willingness of local residents to respond questions of the survey. This helped to get so much information, from which the author of the thesis tried to handle especially those, that are most relevant to the topic.

5.1 Results and evaluation of the questionnaire

The questionnaire was answered by 52% of women and 48% of men. The age of respondents was represented as follows: 55% was aged until 30 years and 45% belong to 31 years and over. The survey was anonymous and was not investigated in which part of the city respondents live.

5.1.1 Waste management

63% of respondents knew that the municipal waste is deposited at the landfill. 66% of people search for information on the internet, followed by promotional materials and media reports. 76% of respondents said that in the city is not enough bins for waste. 91,5% considered that the waste management system in the capital of Colombia is insufficient, 40% of them found the system very bad.

Respondents answered on the open-ended question, what they would improve on the waste management, that should be improved the way of waste sorting and promote importance of

recycling. Waste sorting would lead citizens to greater accountability, but respondents also admitted that people must first learn.

97% of respondents is interested in the waste sorting but only 50% of respondents are actively trying to sort the waste, of which most paper and plastic. 43,5% of addressed people sort the waste occasionally and also mainly paper and plastic, only 6,5% of the respondents said that never sort the waste.

Respondents agreed in the „open-ended“ question „why do you think is the recycling important“, that the recycling protects the environment and reduces the impact of human on the environment. Most of respondents also share the view that active recycling reduces environmental contamination and allow more efficient protection and preservation of natural resources.

Half of respondents of „face-to-face“ questionnaire concerned that one day will not be more space in the Earth to storage a solid waste and recycling is one of ways how to prevent this. 100% addressed citizens, including those who are not recycling (6,5% of total) said that recycling is important.

65% of respondents recycle and always use designed trash for the waste disposing, 15% of them recycle only partially, but consider themselves as actively recycling. (evaluation from the 2nd question). These 15% of the population probably recycle only if the recycling system is available, when they have access to bins of recyclable waste (offices, near homes, on the street, ect.) 96% of those surveyed respondents said that is a great shortage of containers for recyclable waste.

Interviewed people said that should increase the number of places where is possible to recycle the waste as well as the number of containers for sorted waste. Furthermore, people report that should raise awareness among residents about the benefits of waste sorting, which need to be more integrated in the households, apartment houses, offices, but also in public spaces such as streets, parks, recreation and sport areas, public transport as well as government institutions and public schools and universities, etc.

98% of respondents said that they know what are biodegradable materials, of which 56,5% is trying to purposely use them.

80% of respondents reported knowledge of materials that are toxic to the environment, of which 43% are those who do not use biodegradable materials.

89% of respondents reported that they know that some materials in nature spread for several hundred years, of which 40% reported that despite this knowledge, does not use biodegradable materials.

5.1.2 Wastewater

The second part of the questionnaire focused on the wastewater. It was found that 87% of the surveyed population is interested in the quality of surface water. 85% of the respondents is aware that the quality of the surface water affects the quality of agricultural products and potable water, 10% of them are those who are not interested in the surface water quality. All respondents (100%) would like clean water in river canals of Bogotá city and decotamination of Bogotá river.

45,5% of respondents answered on the question if they use non-toxic detergents for the environment (washing, cleaning, ect.), that try to use this products at home, the same percentage of respondents reported that rarely use them.

85% of respondents considered that is a lack of these products in chain stores and 72% do not know where to buy these products. 28% of those surveyed who knows where to buy these non-toxic chemical products reported, that these products are accessible in special stores or big retail chains. In addition, they said that is not enough of these products on the market.

28% of those surveyed said that the barrier to buy non-toxic products for the environment is their higher price. The barrier of buying these products see 52% of poeple in inaccessibility. Only 6,5% does not believe in the functionality of environmentally friendly products. 13,5% of respondents said another reasons without any specifics.

6 Discussion

This thesis deals with assessing the impact of the city of Bogotá, the capital of Colombia on the environment and agricultural activity. Attention is paid to methods of solid waste management and wastewater treatment. The work is focused more in theory than in practice and is familiar with a given environment, focused on a survey of local conditions and personal contacts with inhabitants of the city. The thesis includes the collection and sorting of documents with an effort to maximize their credibility and completeness. The goal of the thesis is to find appropriate solutions as well as possible improvement.

In every state is elected a separate policy to protect the environment, however, principles of sustainable development are global, so any country in the world cannot be isolated in this topic. Colombia has the environmental protection anshrined in the Constitution, laws and regulations. Compliance with legislative rules must be carefully controlled, but audit institution, except the judiciary, are not common in Colombia.

Waste management and wastewater treatment system is limited by technical and economic possibilities and is handled differently in every country. This is subjected to specific local historical, natural, geographical, political and demographic conditions and to the different economical, technical and social aspects. The successful solution of these problems depends on many factors, some of them can be predicted and affected by the right decisions, but not all of them. Some of the factors are historically conditioned and for their change we must considered long-term horizon, e.g. the education of citizens to change their habits can take many years. Other factors depend on natural conditions. For example landslides and floods in Bogotá city are very common, however, their size can never be accurately determined in advance. It is also always necessary to consider if the economic costs of specific measures to avoid environmental damage or risks will be outweighed by their expected benefits.

It should be also seek to introduce the best available techniques and avoid repeating of mistakes that have already been technically overcome (landfill gas explosion, etc.). Integration of systems for the waste management and the water purification into the city or land should be as much environmentally friendly as possible. Very difficult is the elimination of old environmental burdens, and remains of earlier inadequate interventions into the nature or the countryside. More effective is prevent the environmental damage than dispose the damage with the large financial cost afterwards.

The author is aware that during his short stay in Colombia he could not identify and describe in detail all problems in the country. Natural, historical and political conditions are very different from existing knowledge and experience of the author. Access of completed information was chosen as objective as possible to eliminate this weakness. In addition to literary sources was used personal on-site investigation.

Questionnaire was conducted among citizens of Bogotá city and should show how are citizens interested in environment issues. Respondents were asked questions related to the waste management and the wastewater treatment. Approximately equal numbes of women

and men were interviewed. The willingness to answer the question was not different between men and women. It was found that the awareness towards the environment is same between the sexes. For this reason, the answers of respondents are not divided by sex. The ratio of people under the age of 30 years and 31 years and above was approximately the same. The questionnaire found that people over 31 years are more interested in environment issues. The group of older people showed a greater knowledge of the waste management system of Bogotá city and greater awareness of environmentally friendly products than younger people. This finding contradicted author's expectations because a greater concern for the environment was expected among younger generations in consequence of influence of modern trends of healthy life style and education in schools. This finding may indicate that ecology is a neglected topic in Bogotá city and projects focusing on education of the citizens, particularly the education of pupils and students, are missing. Definitive conclusions in this sense cannot be done from the realized survey, since the questionnaire did not include questions of this nature.

6.1 Field of the waste management

A majority of respondents considered waste management system in the capital as insufficient. Many people reported that in the city is not enough bins for municipal waste. The opinion of respondents is supported by the author's observations, which verified that in the public places, public transport and on the streets is insufficient amount of bins. In general bins occur rarely in the city. It is quite common that people throw waste on the street. Scattered garbage is seen almost everywhere. The reason for this state author sees in a lack of motivation and education to maintain the public cleanliness and in the failure to create satisfactory conditions for waste collection.

The questionnaire identified a obvious need for people to improve waste management system, especially the way of the waste separation and recycling. The questionnaire showed that people do not consider the state in the city as sufficient and they are interested in improving of the current situation. People know that all depends on the responsibility of each individual and that all depends on how they behave. If the answers of respondents reflected their actual behavior or were rather more the expression of their wishes could not be evaluated. At first sight when walking round the city of Bogotá is clear, that the system of environmental responsibility of individuals does not work in practice yet.

Most of the interviewed residents of Bogotá city were interested in recycling, but only half of them is actively trying to sort the waste. Other residents sort the waste only if they have the opportunity, only a small portion of respondents do not sort the waste at all. The most sorted material is paper and plastic. Respondents agreed with the opinion that recycling reduces environmental impacts. The awareness of citizens of Bogotá city about the usefulness of the recycling is substantial, although the system of the sorting and collection of the sorted waste does not work properly. In poor areas of city this system is not implemented.

The survey suggests that people separate the waste only when containers for recyclable waste are available. People would probably sort more if they had more suitable options to do so. Most respondents said that there is a considerable lack of containers for waste sorting and that should be increased number of these containers, where the sorted waste could be put.

The author found out that residents do not put each type of sorted waste separately, but together in one basket for recyclable materials. So they combine glass, paper and plastic. In order to improve and make waste sorting more effective should be each type of waste collected into different types of trash bins, which could be distinguished by colors or otherwise significantly labeled. The current situation is not satisfactory because must be made further waste separation in order to use this waste for standard recycling.

In front of family houses are located wire baskets where people put bags of rubbish, place for recyclable waste is not located. In the residential houses are located containers for sorted and unsorted waste in the basement. Before the collection of waste these containers are put on the street and taken back again into the basement afterwards. Before the collection of waste poor people are passing through streets with carriages pulled by horses, called "zorras" or pulled by human „zorros“. Those people separate and collect materials, which they could sell in the collecting yard. Those people stop and sort waste in front of houses or carry all bags away and sort it elsewhere. Resorting on spot is made mostly in front of family houses, where they have the time for separation. Before residential houses, which often have a doorman or guard service are those people expelled, because they leave scattered garbage after the separation. In this case, carriage passes slowly through streets and small children run around and throw the whole bags on the carriage. "Zorras" then stop at river banks, parks, streets or under bridges, where they sort the waste."Zorras" often

meet in these places and exchange different materials, depending on the type of collected material. At these places is left a lot of scattered waste because these people leave the rest of unneeded waste.

At these places is often not only a garbage mess, but sometimes also a criminality. Waste is spreaded around by the wind or washed by rain water into the river canals and washed away into the river of Bogotá. The current system of waste sorting is used mainly by people, who has the only income from the collection of secondary raw materials and it is not actual preparation of waste for recycling. City management should focus on places where "zorras" exchange the waste and prohibit this activity. This would prevent the spreading of waste and limite the pollution of public areas of the city and surface water. Prohibition would also save subsequent expenditure associated with disposing of this illegally collected waste.

Sorting of waste implemented in Bogotá city has rather the opposite effect than it should have. The positive is that people are aware and develop pressure on the city government to improve this system. Tender for selection of contractors for public services, which was listed in the end of the year 2011, was canceled by the court because of the criticism of waste sorting methods.

The city of Bogotá has one big landfill for municipal waste called Doña Juana, which in operating 24 years. After the explosion of LFG at the landfill is paid a great attention to safety issues. The city learned from the mistakes and try to operate the landfill in a modern way. The landfill is covered up and closed parts are recultivated. LFG is collected and combusted and all landfill water is cleaned. The main components of LFG are carbon dioxide and methane, which are the most important anthropogenic emission substances acting on the global warming and the greenhouse effect. Free LFG leakage into the surrounding atmosphere cannot be accepted. In this way is possible to rate the current dump security positively, because landfill gas is combusted and greenhouse gases are therefore restricted.

Problems of the landfill remains in its old parts, which are not technically well secured. Another big problems are connected with natural conditions, particularly heavy rains causing massive land slides. This is always immediately death and damaged landfill sites are fixed.

Doña Juana landfill is not well secured against the entry of people and animals. Most parts are not fenced and where the fence is located, can be easily overcome. A common phenomenon at the landfill is the number of people and animals entering the landfill and even on sites that have not been recultivated yet. Domestic animals, especially cows, can be seen eating deposited waste. People and animals are becoming vectors and can become agents of infectious diseases. The current situation suggests that a landfill operator is unaware of this problem or does not know what consequences can be connected with this problem, otherwise CGR would have better tendency to secure the landfill.

It is gratifying that the company CGR, which operates the landfill, focuses on social assistance in areas adjacent to the landfill. CGR is trying to improve the living standards of people living near the landfill. The company assumes responsibility for the impact of operating the landfill on the surrounding residents. It seeks to contribute sustainable development by promoting balance between its economic growth and social areas. CGR expressed effort to show people the importance of the landfill and its necessary operation, that use all available options to reduce impacts on the environment. The company is open to the public and includes environmental education, awareness and organizes excursions as well as is open to the media. Operation of the landfill gives employment to people from poorer areas of Bogotá city. Residents of the city do not protest against its existence and location. Residents are probably aware of its necessity. The concern is the possibility of over-expansion of the landfill and its large space requirements. The landfill occupies the former valley that people remember and therefore have a comparison with the original look of the valley. The media brings regular information about the operation of the landfill and its problems and openly deal with this issue. In many ways, we can say that the state of the landfill is better than in some more developed countries.

6.1.1 The proposed improvements in the field of the waste management

The city should expand the routes of collecting the sorted waste and unify the system. Containers for recycling should be located outside on the streets, where people could bring and dispose the waste. Containers should be located near residential houses, schools, institutions, parks and public transport, so that people could sort commonly on the street and not just at home. City leaders are aware of this problem and this probably promotes the

plan of placement of bins on the streets, which will be included in the future tender for selection of companies for public services.

The author of the thesis proposes to modify the design of bins for sorted waste located on the streets, to be protected against the stealing of waste, in order to be possible to throw waste into the container and not to be taken out. The containers could be built underground and above the ground would be situated only the place for waste dispose (like some containers in the city center of Prague). This would prevent stealing and taking the waste away. Placing containers underground is expensive, so these underground containers could be placed only in the city center, close to parks and places of the rest. Underground containers would eliminated waste spreading and aesthetically would not disrupted the environment of public places, streets or parks and elsewhere, where the appearance of bins is undesirable.

Because the waste could not be used by socially weak citizens due to secured waste containers, the author proposes that people who live from waste sorting would be integrated into the waste sorting system effectively and organized, not spontaneously as nowadays. The current system of waste sorting is the only source of financial income for many people. If those people, who are economically dependent on the waste collection would not be included in the waste management system, it would lead in increases of the poverty and crime. Requirement for integration of these people into the system of waste sorting was the main reason of cancellation of last tender, which was listed in the end of the year 2011. The tender was cancelled because of the fear of losing the livelihood for these people, not for the reason of improvement of the system.

The city should promote the importance of the waste sorting more and consistently educate people to maintain cleanliness in the city. By personal contact with citizens, the author discovered that people often do not see city of Bogotá as their home, but only like a place where they work and spend the working week. At the weekend people leave the city to their original towns and municipalities around the Bogotá D.C. Certainly would be helpful if the city government donated funds for educational campaign to show to people that the city of Bogotá is not only place where they can find the work. People would be able to develop a better relationship to the city which is as well their permanent or temporary home. The home should be well-cared and kept clean and therefore beautiful.

A majority of respondents know what are biodegradable materials, but only about half of them are trying to use them. The second half of the respondents are not interested in using of these materials, although they are aware of their importance for reducing the risk of environmental pollution. The reason of disuse of these products is their higher price and their common unavailability. Probably there should be pay more attention to the promotion of naturally degradable products for the purpose of integration into the current consumer system. It would also be appropriate to ensure greater awareness of residents about the impact of the materials on the environment, such as realization of campaigns on the use of environmentally friendly materials. Alternatively make pressure to reduce consumption and the use of non-biodegradable materials. From this perspective would be also necessary to change the current way of goods packaging, especially for large retail chains, which is done very inappropriately. All goods are packed in lot of plastic bags (HDPE, LDPE), which are so greatly wasted. It would be useful to focus on the education of people to reuse their own bags, because the vast majority of people is not using own bags. The author suggests, that HDPE and LDPE bags would be available only on purchase at retail channels and not free to take as nowadays, so their circulation would be greatly decreased. This would eliminate the massive consumption of HDPE and LDPE bags, because certainly people would not want to pay extra for bags, by this they would learn to carry their own shopping bags when going shopping. It would also be suitable to allow the use of only bio-degradable wrapping papers and bags in supermarket chains. The commercial promotion could be included in the sale of promotional bags stimulating people to re-wear them. In this project, which promotes ecological behavior, could be included e.g. art schools, universities and educational institutions and also public so, the production of these bags could be combined with teaching. The government of Bogotá D.C., for example, could list an art competition on the design of these bags. It would more easily contribute to engage people in environmental issues and waste management. The author of the thesis himself offered several people so called greenbags (bags that are folded into a small bag and so, can be constantly carried in the handbag) in order to test their applications. The author met with a positive attitude towards these products. People said that these bags are „very smart“, but the city does not offer such things. Environmental education is usually financially demanding and time-consuming and the city government would have to participate in it. The result of such education would be a smaller production of waste and its more favorable composition.

City of Bogotá disposes waste on the landfill Doña Juana, where LFG is combusted. LFG is also a highly valuable energy source and can be very versatile and effectively used. It is therefore pleasing that is planned its use for electricity production, even only for the purpose of the landfill operation. With regard to the quantity of gas production, could be used not only for the energy purpose of the landfill operation, but the excess of energy power could be sold into the electrical grid. LFG can be used by more versatile way than it is used now.

Recultivation of the landfill is made only by grass, it would be good to use for recultivation as well local tree species, this measure would better protect the landfill slopes against the soil erosion.

The author of the thesis considers the current solution of fencing landfill as insufficient and is convinced that infiltration of humans and animals to the landfill must be avoided for health reasons. Around landfill should be built solid fence, mainly around not cultivated parts of the landfill. The fence should be also regularly checked that there is no breach of its integrity.

One way to efficiently dispose the waste is the waste incineration. Municipal waste incinerators are now equipped with an effective combustion gases cleaning and emission control. Sulfur dioxide, nitrogen oxides, heavy metals and polychlorinated biphenyls in the flue gas are captured in modern waste incinerators. The incinerator would solve the problem of the increasing amount of the municipal waste and problem with the limited life of the landfill. The author believes, that the filling of the new valley with waste in such extent as it is happening now at the landfill Doña Juana, is unacceptable for the future. A better system of classification, functional recycling, incineration, or at least partial incineration of the municipal waste, which is already pre-sorted would greatly helped to the waste management system. Construction of municipal solid waste incinerator is expensive and its integration into the landscape and its construction is not always received with positive feedback. However, the city of Bogotá with so many residents cannot count only with the creation of municipal landfills for the future. Landfills are very demanding in terms of space. Municipal landfill Doña Juana has a lifespan of 10 more years now, and therefore the city should now focus on the question of future waste management. Incineration of municipal waste combined with recycling, or even landfilling seems to be the best solution.

6.2 The field of the water pollution

The biggest environmental problem is the city's wastewater. Wastewater from industry is purified before discharge into the environment. The lack of sewer system causes discharge of household's wastewater without any treatment directly into rivers. Only 20% of domestic wastewater is treated. The contamination of tributaries of the river Bogotá by wastewater has resulted in so big pollution of the river Bogotá, that this river is completely without aquatic life and its color is dark black with a white foam on the surface. Surroundings of the river is almost uninhabitable due to contamination and the strong odor. The only residents of river banks are dwellers of slums.

Nowadays, the most important construction for the city of Bogotá, are collectors and sewer system, which will lead into the individual collectors. This is a critical step to reduce current massive environmental pollution and prevent spread of infectious diseases. City of Bogotá lies in an exceptional natural area, which should be protected. City is looking for a gently way to connect city life with surrounding nature.

WWTP Salitre is connected by collectors and the sewer system brings waste water from homes to the WWTP. However, these collectors are only in the northwestern part of the city and do not cover the populated east of the city. South of the city is completely without any sewers and wastewater flows directly into rivers in the city, which flows into the river Bogotá. This results in a strong odor in areas adjacent to rivers. These areas has no value due to dirty rivers and are mostly populated by slums and buildings without a building permit. The land on the banks of the rivers could have a high value and be a nice place for living.

Pollution of tributaries of river Bogotá by wastewater has also results in massive pollution of wetlands. In these wetlands contaminated water is accumulated and contaminates the environment around. Further, there is also accumulated solid waste. Author of the thesis can confirm from his own experience, that most wetlands stink and the strong odor is spread to the surrounding areas and thus are degraded living conditions of adjacent residential houses.

It is very good that the city has begun to build collectors, which will in future gather and deliver wastewater to WWTPs. For a city is crucial to separate wastewater from surface water. This would have significant cleanup effect for the rivers in the city, because the

water in the rivers would no contain the biological contamination from households. This would also reduce the odor from rivers and wetlands. Decontamination of rivers would make possible return of aquatic life in these areas and increase the value of adjacent land. It would also improve the quality of life in the city (creation of zones for recreation, sports, etc.). Government of the city should monitor and sanction any contamination of watercourses. The wetlands should become protected, educational and recreational zones. The city should also focus on the drastic filling of wetlands with debris and other waste in the illegally growing parts of the city.

As part of documentation collection was found that the city of Bogotá has decided to clean and adjust the canal of Bogotá river. This ambitious and extensive project envisages with dredging of the river bottom and extension of the river basin and flood zones. Project envisages to create floodplain forests around the river basin. The project also allows repairing and cleaning defunct meanders and wetlands. A large strip of vegetation will be built along the river Bogotá and near the city, within the project. Project also include constructions of dams protecting the city of Bogotá against floods. On these green areas are calculated constructions of recreational and sports areas as well as with children's playgrounds. Running and cycling path will be built along the river bank. This project will return life to the areas around the river and improve the quality of life of people living nearby. The author considers that this project could partially balanced the „*estrato*“ difference between the inhabitants of the south and north part of the city.

It was found from the questionnaire that a large part of the respondents is interested in the quality of surface water and know that its quality affects the quality of agricultural products and potable water. All respondents would like, if the water of river canals in Bogotá city and Bogotá river itself would be less polluted. People negatively perceive that the water in rivers flowing through the city is visibly black, dirty, with a foam on the surface as well as the heavy odor. It is therefore understandable that people are not satisfied with this situation.

When asked whether respondents use environmentally friendly washing and cleaning detergents, almost half of the respondents replied that they try to use these detergents at home, while others use them rarely. Most respondents stated that there is lack of these products in chain stores or they do not know where to buy them. Higher price is a barrier to purchase environmentally friendly products for third of respondents. Pleasing finding was

that only a small portion of respondents do not believe in their functionality and therefore only a small portion of people would not use environmentally friendly products, even if these products would be commonly at the market. It is a similar situation as in a case of questions focused on biodegradable materials. Again the effort to use these materials appeared. Citizens have a knowledge about benefits of these products but their use is not common. It would be very helpful if these products would be available in the markets and if their prices would be more favorable. It can be reasonably assumed, that most people will prefer and start to use these products. These conclusions, however, does not apply across the board, because the survey was not conducted in the poorest areas of Bogotá city.

6.2.1 The proposed improvements in the field of the purification of the water

The research showed that people would use earth friendly products, but this is prevented by the unavailability and high price of these products. It would therefore be better to focus on the promotion of such products and ensure their availability in mainstream retail chains. Government should also inform people about these products, their quality and effectiveness as well as motivate citizens to use them.

In the field of wastewater treatment, as well as in the case of LFG at Doña Juana, can be recommended consideration of energy recovery of biogas from WWTP Salitre and planned WWTP Canoa. Biogas production is significant in WWTP Salitre, so the expected production of biogas in WWTP Canoa is significantly higher. Energy use of biogas could be economically beneficial and the use of biogas technology is common. Energy production of both WWTPs could make them energy self-sufficient and thereby save the city money, which could fund other projects. The rest of electricity could be sold to the grid.

Water from the river Bogotá is used for irrigation of agricultural areas on the right river bank along the Bogotá city. This irrigation is unsuitable due to high pollution of the river. This problem could be solved by using decontaminated water from the WWTP Salitre or Canoa. Discharges from WWTPs could be connected to the irrigation system. This would limit the use of health hazardous water from the river Bogotá, which contains substantial quantities of pathogens.

The planned separation of the wastewater from the surface water in Bogotá city will not prevent water contamination by solid waste, because people throw significant amount of the solid waste into rivers flowing through the city. Another significant way of contamination of the rivers by solid waste is due to winter and rain water. Water level in river canals increases during the heavy tropical rains which washed all of the scattered waste from surrounding areas into the river canals. The river banks are then heavily polluted not only by wastewater, but also by the solid waste that people throw away. This solid waste is floated on the surface of the water and flow into the Bogotá river, further into the river Magdalena, which leads into Caribbean sea. The author see the possibility to improve this problem by installation of screens into river canals located in Bogotá city. These screens would capture the solid waste floating in the water to minimize the pollution. This project would eliminate contaminating of Bogotá river by solid waste. These screens would have to be regularly cleaned and be limited in height in order to avoid blockage and prevent flooding of the near areas. These screens should be also installed at water entrance of wetlands to prevent contamination of their ecosystem. Another improvement could be construction of stairs (rapids) at bottoms of river canals to provide aeration of the water, thereby increase self-cleaning ability of water which would slow down growth of anaerobic bacteria. This procedure would increase the self-cleaning ability of the water of all rivers that flows through the city.

Recultivation of the river basin and cleaning of the wastewater in the Bogotá city will greatly improve the situation. However, the water of Bogotá river will not be cleaned up completely due to its heavy contamination before entering the city of Bogotá. River Bogotá already produces a strong odor. The author believes, that if the river will not deprive of its odor, river banks will remain still uninhabitable. Unpopular zones would became from river banks, which would started to be occupied by only socially weak citizens, as is current situation. This situation could also create river banks as a dangerous zone. If the Bogotá river would be completely purified, river banks would be a desired address for the entire length of the river and the life on its banks would change for better. All respondents in the survey expressed the wish to purified the river Bogotá, which makes this problem highly topical.

There are three major suburbs called Cota, Chia and Cajica, before the Bogotá river entre the city of Bogotá, without proper wastewater treatment, so the wastewater is discharged

directly into the river Bogotá. Author believes that this problem would be solved by construction of WWTP common for these three towns. The author has an opinion that under conditions of clean river Bogotá before entering the Bogotá city and fully well operating wastewater treatment system in Bogotá city, the life could be returned into the Bogotá river and on its banks. Fish could be then reared in the purified river.

WWTP near the cities could clean all wastewater from these three cities (Cota, Chia, Cajica) and possibly also the water from the river Bogotá (of flow about $12\text{m}^3/\text{s}$ in this sector). It could collect water from the river Bogotá in order to clean it and return purified and decontaminated back into the original river basin. The dam would have to be designed to prevent possible flooding. For example in case of increased water level, the water may flow out without being cleaned. By this would not be necessary to change and modify the river canal. The author is aware that any interference in the watercourse has a wide environmental impact. However, because of the present absence of aquatic life in the river Bogotá, would WWTP not affect migration of aquatic animals. The author is also aware of the high cost of such project, but believes that the environmental benefits for the region would be much higher. Construction of common WWTP might be financed by participating towns and also by the region of Cundinamarca, by which Bogotá river flows through. Water from the river Bogotá is also greatly used for agriculture purposes in the whole territory, so its purity should be in the interest of the whole region.

Once majority of the cities in Bogotá river basin would have built own WWTP and only purified wastewater would be discharged into Bogotá river, could be reached a desired water quality level. The proposed WWTP would serve only for the purpose of towns Chia, Cota, Cajica and the process of cleaning the river water would be stopped. Uninterrupted water flow could be returned to the river Bogotá.

Columbia and especially region of Cundinamarca should more consistently check the implementation of laws involved in protection of watercourses as well as oversee that every municipality has its own WWTP and that wastewater is not released into the environment.

7 Conclusions

The survey suggests that addressed residents of Bogotá city are interested in ecology and that problem of the waste management and the cleanliness of rivers is not indifferent for them. From the survey was found that surveyed population is willing to use environmentally friendly and biodegradable materials but do not have created appropriate conditions such as availability and favourable price of these products. The questionnaire also showed the need of people to change the current state, improve the method of collecting and sorting waste and introduce recycling. The overwhelming consensus was found in the need to improve the purity of water in rivers and change the current massive pollution of the surface water. The interest in ecology, waste sorting and recycling cannot be assumed among the poorest inhabitants, who were not included in the questionnaire. These people rarely go shopping and everything what they purchased try to maximally use, so these people are not big producers of the waste. These people are probably more interested in clean water in rivers because they are dependent on the surface water. However, it is unclear whether they ever realize the seriousness of the water pollution and health risks connected with use of hygienically unsafe water.

Waste management system in Bogotá D.C. is a functional, city cares about the waste management and tries to solve this problem gradually. A weakness of this system is inadequate and inconsistent organization of waste sorting and recycling. The collection of sorted waste is not realized in all parts of the city yet as well as is not well organized. Trash cans are not placed in all public places. Another area that needs improvement is cleaning the city and collection of disposed waste on the streets which are not cleaned. Currently is listed the tender for the new service provider, according to which the waste collection and cleaning of the city should be done in all city parts. At the request of citizens will be addressed for the next period a better system of waste sorting and its subsequent recycling, in which will be integrated poor city dwellers. By improved method of sorting and recycling the waste, will be reduced a total content of the waste disposed on the landfill. Landfill will not be filled so quickly and its demand of the space will be smaller and life of the landfill could be extended. However, the city should now begin to focus on the problem, where to store the waste in the future after closure of the landfill Doña Juana.

In the thesis was found that the fencing of municipal landfill Doña Juana is insufficient. Boundaries of the landfill is necessary to secure and prevent the penetration of humans and domestic animals into the unrecultivated and operating zones, where environment is not hygienically suitable for the movement of people and animals. If cattle is grazed on the rubbish, the quality of agricultural production is such dubious. Already recultivated landfill part may not be fenced.

To ensure order in the city and prevent accumulation of waste on streets is necessary to put bigger number of bins on public places and should not be missed even bins for recyclable waste. People will undoubtedly sort the waste if they have that opportunity. It would be good to create different coloring of bins for recyclable waste for each sorted material, so that people could easily recognize where to put the waste. In wholesale chains should be limited excess distribution of plastic bags (HDPE, LDPE), what would lead to less production of the waste. It would be beneficial to do not pack all goods into big plastic bags, but into bags corresponding the size of goods as well as use of paper packaging or easily degradable materials.

It is necessary know that education of citizens to change their behaviour takes a long time, but it must begin. Into the process should be involved the city government, through its institutions, schools, etc. – e.g. targeted campaigns with educational themes, promoting the ecological behaviour of people and companies, etc. The city itself may also regulate the use of certain undesirable products. It would be useful to introduce environmental education in schools, because children often affect the behaviour of parents more than the perfect campaign.

The author found that with the exception of the poorest parts of the city, where he could not realize the survey, people are willing to improve the situation. Citizens are willing to sort the waste and use the bins. The willingness to use biologically degradable materials is not so obvious. There is probably necessary to create better conditions for their use and awake the motivation of residents about these products.

Wastewater treatment exists in Bogotá city, there is built a WWTP Salitre, which is insufficient to purify all wastewater from the city. Legislative rules are given for the treatment of wastewater from the business sphere but because of the not built sewage of household is the whole wastewater system ineffective. The Bogotá river and other rivers in the city are filthy sewers without present of life and filled by solid waste. City leaders are

looking for solutions, but problems of surface water pollution are so serious, that cannot be said with certainty when the state can be fixed. The first evidence that the city decide to do something about the poor condition of the river Bogotá is the project of the sanitation of the river canal adjacent to Bogotá city. This project is designed to recultivate river meanders, wetlands restoration and establishment of floodplain forests. Whether it will suffice to return the life into the river Bogotá cannot be determined, but can only hope. None of rivers end in the city of Bogotá and carry the water pollution further into other rivers and the sea. The problem of the river pollution goes beyond the city boundaries and become a problem across the country.

Contamination of surface water affects the surrounding environment. Rare wetlands that where once the pride of the local landscape, are largely destroyed and the typical animal habitats of wetlands disappears. Nowadays many wetlands are smelly places, which people avoid. These wetlands should be recultivated and significantly linked with dynamic rhythm of the life in the Bogotá city. These zones of wetlands could be favourite relaxation, instructive or just naturally protected areas, which would form a unified whole of the city.

Pollution of the rivers cause serious problems in agriculture, which is dependent on the surface water. The irrigation system use polluted water, which then reduces the quality of the agricultural production, but people farming in the vicinity of the rivers have no other choice. This problem could be partially solved by the connection of the treated wastewater from WWTPs and the system of irrigation.

The city must quickly finish the sewer system and separate the wastewater from surface water, where should be only discharged treated wastewater. The city should also prevent floating of the municipal solid waste into the river Bogotá, which contaminate all Bogotá river basin. The implementation method of wastewater treatment in Bogotá city, however, does not solve fully the problem of Bogotá river pollution, because the river Bogotá is already heavily polluted before entering the capital. The issue of the pollution of surface waters should not be solved only by the capital, but also by the region of Cundinamarca by strict supervision over observance of legislation involved in the environment. Only by the observance of correctly set wastewater legislation can be ensure sustainably of the purity of surface waters and thereby restore and maintain the life in the river of Bogotá.

In conclusion can be said that the city of Bogotá is struggling with the issues that most world cities have. This city is located high in the mountains, clamped by alpine massifs and its urban growth is very limited. The rest of the unique nature still remains in the city and suffer from the number of people who live in the city. Problems with waste and sewage were not solved for many years. Generation of municipal waste and wastewater is considerable and the city is trying to solve these problems. The change for better can be seen in the waste management. In the case of wastewater, the situation is dismal and so far the possible solution of the situation is only in the discuss or in projects. Perhaps the results of these efforts to remedy will appear before long, the author of the thesis would have been very pleased.

Prague, 15th April of 2012

Bc. Filip Šinágl

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Note:

Motto of this thesis is the question about the order in city of Bogotá. The answer is hidden in words of Audrey Hepburn: *„If we want to do something for the nature, first we must fully understand the nature and if we want to improve something, we must begin“* (Paris,2005) – Bogotá city has begun.

Prague, 15th April 2012

Bc. Filip Šinágl