CZECH UNIVERSITY OF LIFE SCIENCES PRAGUE

Faculty of Tropical AgriSciences

Czech University of Life Sciences Prague
Faculty of Tropical AgriSciences

Proposal of Auxiliary Water Purification Unit of the Main Water Treatment Centre for the Capital Town Conakry – Guinea /Yessoulou/

Master's thesis

Prague 2016

Supervisor:
doc. Ing. Vladimir Krepl, CSc.

Author (2016):
Bc. Kadiatou Traoré

Declaration

I, Kadiatou Traore, hereby declare that this thesis entitled Proposal of Auxiliary Water Purification Unit of the Main Water Treatment Centre for the Capital Town Conakry – Guinea /Yessoulou/ is Author (2016) work unless otherwise referenced or acknowledged.

In Prague, 22nd April, 2016 …………………

Bc. Kadiatou Traoré

Acknowledgement

I would like to express my gratitude to my supervisor doc. Ing. Vladímír KreplCSc, for his leading, valuable information, advice, and for the time he dedicated to me during the time I was writing my diploma thesis. A special thanks to Ing. Malis representative of the company PROTE, for his advices, consultations, and his help about all technical matters; also to Mr Vivier from SEG (Societe des Eaux de Guinee) and his team for their help during the data collection and laboratory analysis. Special acknowledgment to the different ministries in my country for the permission of using their facilities for my work, to Mr Camara and Nabe for their guidance about a "know how" of data collection; to Dr Dioubate for the support he provided to me to continue with my master thesis. Last but not least, I would like to thank my family, my friends and specially my husband for their encouragement and patience during those difficult days of writing my thesis. Thank to you all once again.

Abstract

Guinea is the country known as the water tower of West Africa, but unfortunately it does not reflect the access to drinkable water within the country. For this case study, the focus was on the capital Conakry, as it is one of the places in the country where people subscribe to get access the drinkable water. In Conakry, more than 80% of the water supplied to the consumers comes from Grande Chute treated water (ground water from the mountain). The raw water coming from the Grande Chute in treated in the Yessoulou facility. Yessoulou represent the biggest water treatment plant supplying drinkable water to the capital Conakry. By producing a large amount of drinkable water, the facility failed to accomplish the required standard for the quality. Therefore the research focused on analysing several samples collected at different points. From the result obtained, two critical points were highlighted. Based on those points, a design of auxiliary water treatment unit was made, and for its implementation there would be use of modern water purification technologies such as Electrocoagulation device (in the lake where the raw water for the treatment centre comes from) and ASOR module (in the disinfection stage at the end of the treatment) to guarantee the high quality of Yessoulou produced water.

Key words: Water supply, Guinea, Water quality, Water purification technology, Yessoulou

Table of Contents

Tables

Schemas

Figures

Abbreviations

SEEG	Société d'Exploitation des Eaux de Guinée (Guinea Corporation of Water Use)
SEG	Société des Eaux de Guinée (Society of Guinea Waters)
SONEG	La Société Nationale des Eaux de guinée (The National Society of Guinea Waters)
TDS	Total Dissolve Solid
TSS	Total Suspended Solids
EC	Electrical Conductivity

1. Introduction and Literature Review

Guinea has a rich and diverse hydrological network which has a potential to support long term development projects and enhance the trade of the country. According to the Ministry of Water and Energy, 82% of the 245,850 km² that make Guinean territory, are drained by 1,161 watercourses which together constitute 23 river basins with 14 international basins (Diallo, 2006).

Since the 1970s, several water resource management related programs and projects have been developed and implemented in Guinea. Unfortunately, the entire actions one after the other has produced little or no positive impact table to minimize the induced pressures on water resources. That makes the access to clean water a luxury, particularly in rural or peril-urban areas (Diallo, 2006).

1.1 General Information about Guinea

The Republic of Guinea, located in West Africa, covers an area of 245,857km2. It is bounded to the west by the Atlantic Ocean and shares borders with six countries which are Guinea-Bissau northwest, Senegal to the north, Mali to the north and north-east, Côte d'Ivoire east, and Liberia and Sierra Leone to the south.

The climate is tropical, characterized by a dry season that last from 4 to 7 months and a rainy season from 5 to 8 months. The average annual rainfall is equal to 1,651 mm and range from 1,200 mm in Haute Guinea to 4,200 mm in Basse Guinea. The average annual temperature ranges between 21℃ and 27℃. Guinea has annual average relative air humidity above 60%, with a minimum of 29% in Moyenne Guinea (Labé) and a maximum of 98% in Basse Guinea (Conakry). Prevailing winds are the monsoon and the harmattan, respectively blowing from the Atlantic Ocean and the Sahara (FAO, 2005).

Guinea has four agro-ecological zones. These regions have different geographical and geological characteristics, and each correspond to particular temperatures, rainfallregime, soil, fauna and flora.

a. *Maritime Guinea or Basse-Guinea*

This is the coastal strip between Guinea-Bissau to the north and Sierra Leone to the south (300 km), with a width between 100 and 150 km. It covers 15% of the total land area. The salt marshes occupy an area of about 360,000 ha, of which 260,000 ha mangrove (the largest in West Africa). The tropical climate is bimodal, with a rainy season that start in April-May and last until November. The country reaches its maximum rainfall in August and may exceed 4000 mm / year in the capital Conakry. The dry season, which is very strong, starts late November (FAO, 2005)

b. *Fouta Djallon or Moyenne-Guinea*

It covers 26% of the total area of the country and with the massifs of Fouta Djallon, the most mountainous region of Guinea. Its altitude exceeds 750 m and in some places such as the axis of Dalaba-Mali which exceeds 1,200 m. Because of this region Guinea is considered the "Water Tower of West Africa". The Dalaba-Mali is home to the Senegal and Gambia rivers in the north, the rivers of Koliba, Rio Grande, and Fatala Konkouré in the west, the rivers of Kaba and Kolenté in the south, and the Niger River in the east. The climate is marked by a relatively high daily temperature variation of up to 19℃ in Labé (8℃ – 37℃). The rainy season is from 5 to 8 months between Koudara and Mamou. The precipitation is lower than 1300 mm in the north and slightly higher than 2000 mm in the south (FAO, 2005)

c. *Haute Guinea*

Haute Guinea covers 39% of the total area of the country (it is the biggest region), is located between the Forest Guinea and the Fouta Djallon on the western edge of the vast basin of the Niger. This region has an average altitude of 500 m, a little marked relief which explain the spread of waterways. The climate is similar to the tropical Sudanese climate with an annual rainfall between 1,600 mm in the south to 1,200 mm in the north. The seasonal temperature ranges from between 14℃ during the rainy season to around 37℃ in the dry season (FAO, 2005)

d. *Forest Guinea*

It covers the rest (20% of the total land area). Its relief is tormented and the highlight of Guinea, 1,752 m, is located in Mount Nimba. The climate is characterized by the exceptional length of the rainy season (between 7 to 9 months) and an average rainfall of about 2,500 mm / year (FAO, 2005)

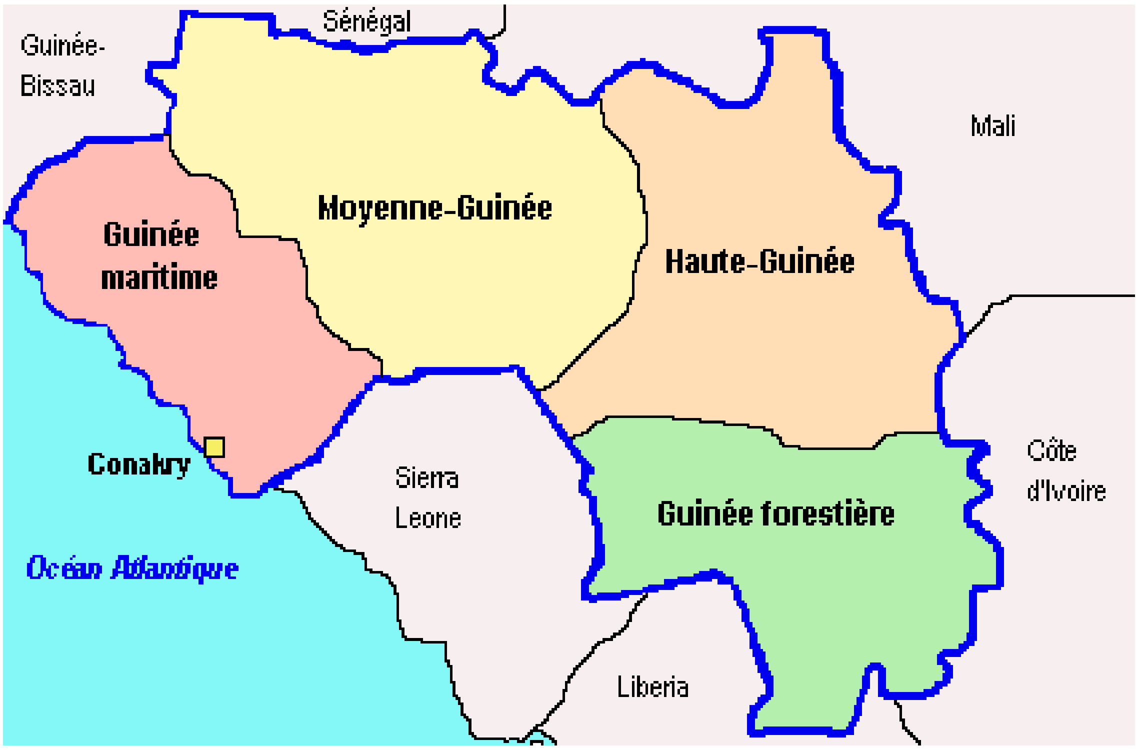


Figure 1: The map of Guinea

Source: CEFAN (2015)

The four geographical regions of Guinea largely correspond to major ethno-linguistic groups. Guinea is inhabited by the Peul (Fulani) which represent 40% of population and are majority leaving in Moyenne Guinea. The Malinké represent 30% of the population, which are mostly in Haute Guinea. The Soussou represent 20% which majority leave in Basse Guinea and the rest is made up of different communities living in the forestry area. Table 1 below shows the 23 river basins within which 14 international basins.

Table 1: Physical characteristics of Guinean river basins

River Basin	**Area in Guinea (km^2)**	**Length in Guinea (km)**	**Coastal States**
Cogon	8,502	379	
Tinguilinta	5,031	160	
Kapatchez	2,906	105	
Fatala	6,092	205	
Konkouré	18,692	339	
Soumba	392	39	
Killy	300	31	
Forécariah	2,226	103	
Méllakhouré	1,049	50	
Kolenté	5,178	210	Gui, SL
Koliba	18,122	407	Gui, GB
Gambie	12,038	211	Gui, Se, G
Bafing/Sénégal	18,672	450	Gui, Ma, Se, Mau,
Kaba	5,427	91	Gui, Sl
Niger	97,168	661	Gui, Ma, BF, Ni, CI, Be, Nig, Th, Ca
Sassandra	10,839	0	Gui, CI
Cavally	2,116	75	Gui, CI
Mani	2,506	157	Gui, Li
Diani	9,333	246	Gui, Li
Loffa	1,684	64	Gui, Li
Makona	8,384	262	Gui, SL
Kayanga-Géba	20	5	Gui, GB, Se
Mano	10	3	Gui, SL, Li
TOTAL	236,687	4,253	

Source: Diallo (2006)

Key*: Legende: Gui: Guinée Conakry; Se: Sénégal; Ma: Mali; Mau: Mauritanie; SL: Sierra Léone; Be: Bénin; GB: Guinée Bissau; Li: Libéria; CI: Côte d'Ivoire; Ni: Niger; Nig: Nigeria; BF: Burkina Faso; G: Gambie; Th: Tchad; Ca: Cameroun.*

Despite all these water sources, less than 40%of the Guinean population had access to drinkable water in the year 1980. To remedy to this problem, the government with the help of the World Bank in 1989 entered into a lease agreement for the operation of private water service sector in the capital Conakry and sixteen other towns and villages.

Two organizations were at the heart of the rental agreement, a national public Author (2016)ity on water, SONEG (Société Nationale des Eaux de Guinée), and a water management company, SEEG (Société d'Exploitation des Eaux de Guinée) (Triche, 1990). As indicated in the Figure 2, SONEG had the task of defining the master plan for the urban area of drinking water, identifying, programming, funding and implementing the projects of drinking water in the urban centres. Also storage of primary networks, production scale, controlling the operations and research of funding and managing the service of the debt sector. SEEG was a mixed company where the Guinean state had 49% of the capital and the private and professional partner of water which is the Saur and CGE of France had 51% of the capital. SEEG had the task of operation and maintenance of water works, distribution and billing of water consumption, collection of bills from subscriber and customer management (Cowen and Penelope, 1996).

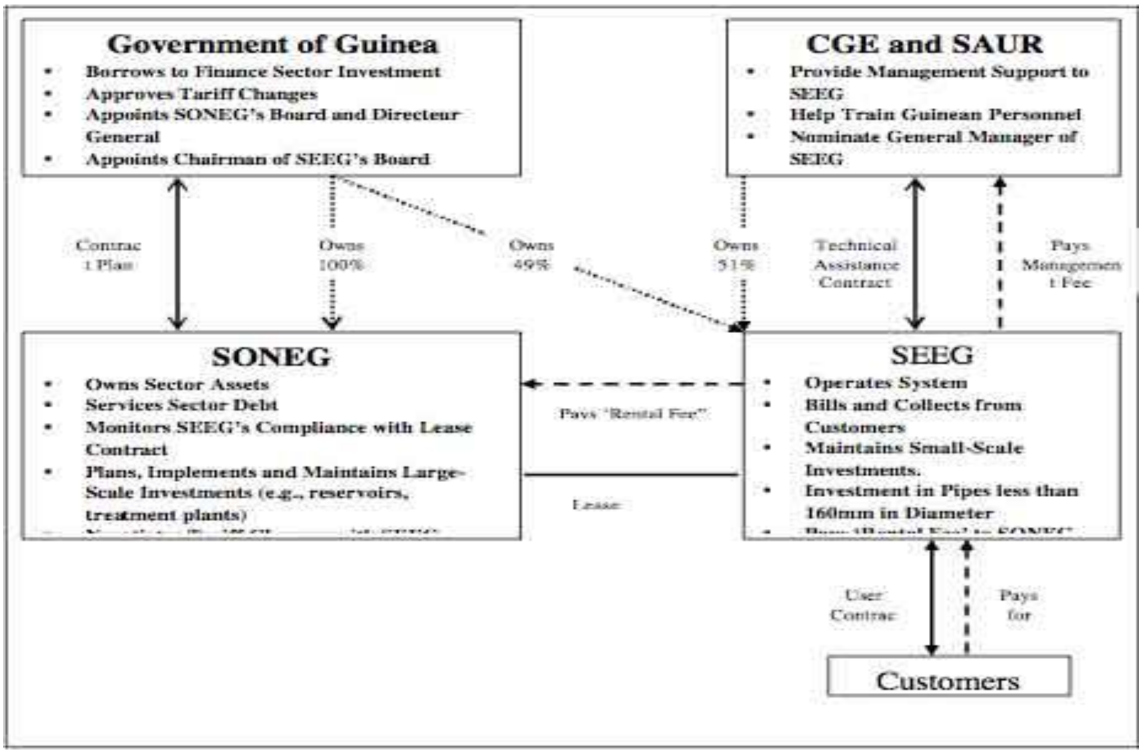


Figure 2: The cooperation between SONEG and SEEG

Source: Menard and George (2002)

The lease between SONEG and SEEG was 10 years. Unfortunately, at the end of those 10 years, the negotiations on prolonging the lease between the two parties failed to yield an agreement as a result of high water pricing demands by the contractors. Consequently, the SAUR left and the Guinean government created in 2001 the SEG (Société des Eaux de Guinée) to replace the two defunct companies to ensure the continuity of water supply to the population. Therefore, the new company took over the entire tasks from the SEEG and SONEG, and at the difference of the 2 others, SEG is a limited company with public participation and governed by a private management mode (Kaneko, 2012).

Therefore, as result of the cooperation between the different sectors responsible for the water treatment, the biggest water purification unit named Yessoulou supplying water for the capital Conakry was build. Its realisation was to improve the access to drinkable water for the population, and took many years (almost 50 years) for the implementation. The implementation was done in different stages, which was to build the first plant (schema 1), than the second a finally the third (schema 5).

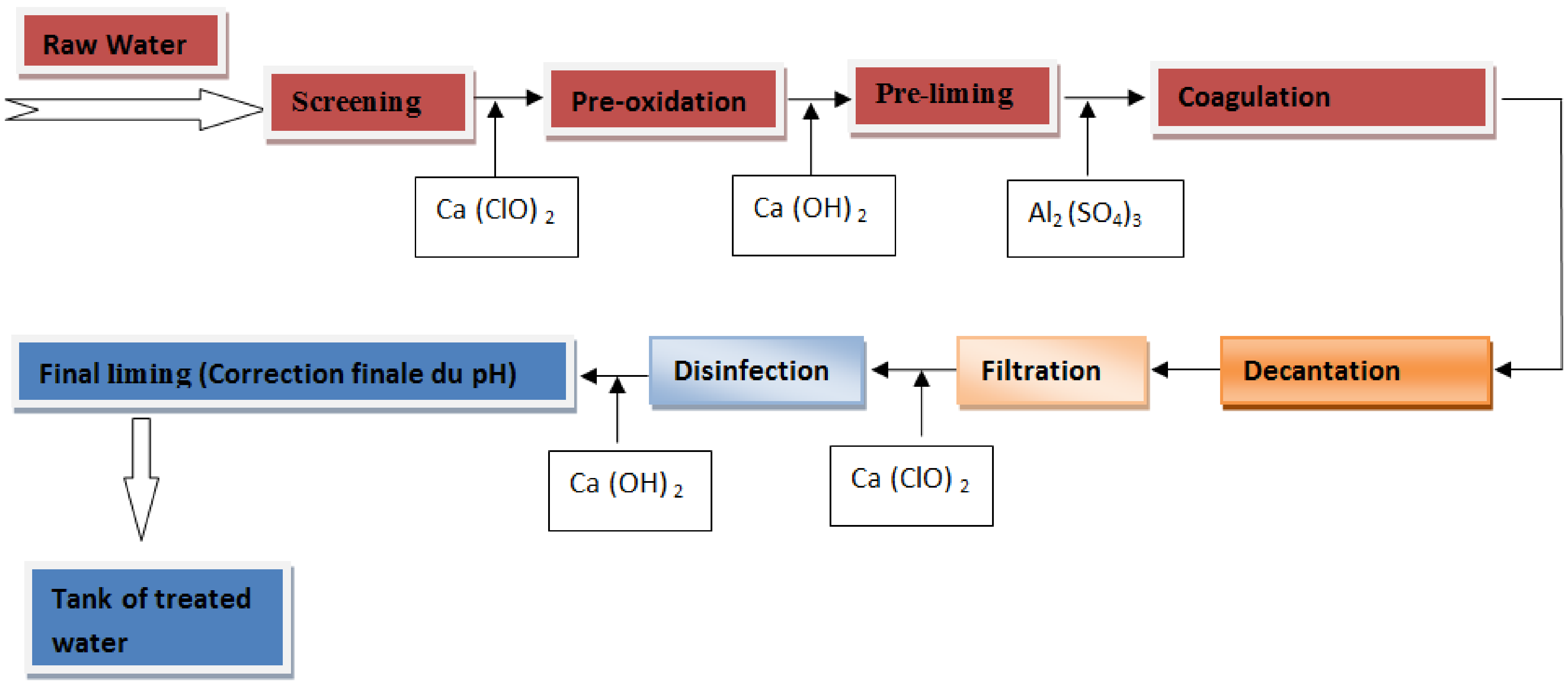
1.2 Yessoulou

It is the largest drinking water treatment centre of Guinea composed by 3 plants which took half a century to construct.

1.2.1 Yessoulou 1

Water treatment plant was built between 1961- 1964.This water treatment plant catered for Guinea Conakry residents. Yessoulou 1 extracts its raw water fromgreat fall called *Grande chute* dam. The treatment capacity of the plant is 50,000 m^3/ day with a treatment cycle composed of 9 stages (schema 1). It also had 3 reserve storage tanks in Conakry: at the Aviation, Belle-vue and Almamya. This first water project was in the horizon of 1975. (Kaneko M, 2012)

Yessoulou1: Capacity of production 51840 m^3 per day



Schema 1: Description of the drinking water treatment for Yessoulou 1

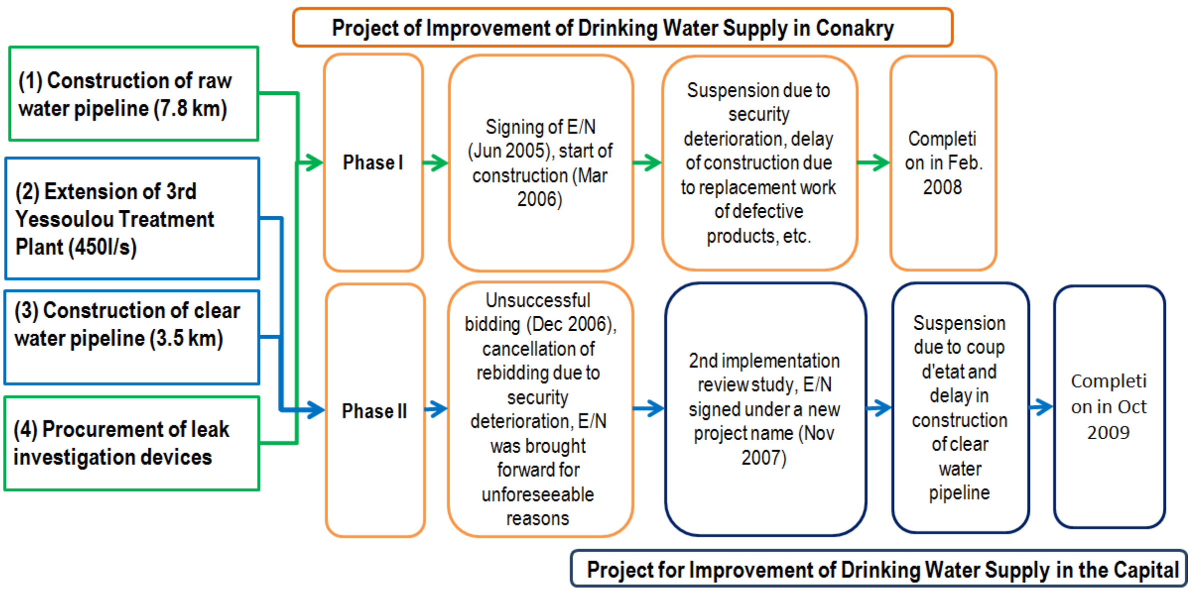
Source: SEG (2015)

1.2.2 Yessoulou 2

The second water treatment plant aiming for the horizon of 1995 was carried out from 1991 to 1994. Executed the work of partial doubling of the pipeline for the raw water, the distance was 36 km between the dam of the *Grande Chute* (Great falls) and Yessoulou, with a diameter of 1,000 mm Ductile Iron. The produced capacity is 37,000 m^3/ day, and to make that possible, the water transport line between the treated water in Yessoulou and Conakry had to be doubled on 23.5 km with a diameter of 1,100 mm ductile iron, also the construction of more reservoirs in Koloma and Symbaya. (Kaneko, 2012)

1.2.3 Yessoulou 3

The third water project initiated in 1995 aiming the horizon of 2005 was delayed till 2009. The reason behind that is the lack of external financing, therefore below (schema 2) is the implementation time line of the project. (SEG, 2009)

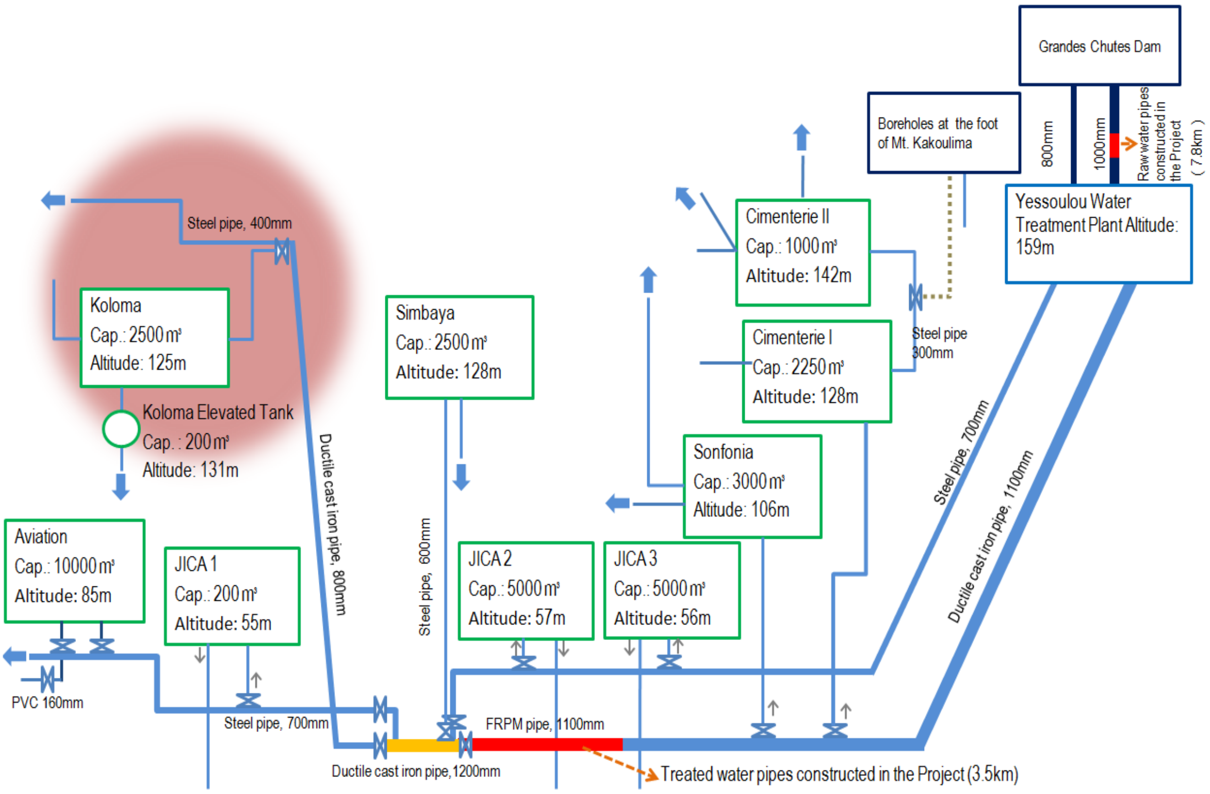


Schema 2: Project implementation period of Yessoulou 3

Source: Kaneko (2012)

With this project, the aim was to raise the water access in Conakry from 65% in 1996 to 80% in 2005. And to do so, some of the objectives as shown in the schema 3 were:

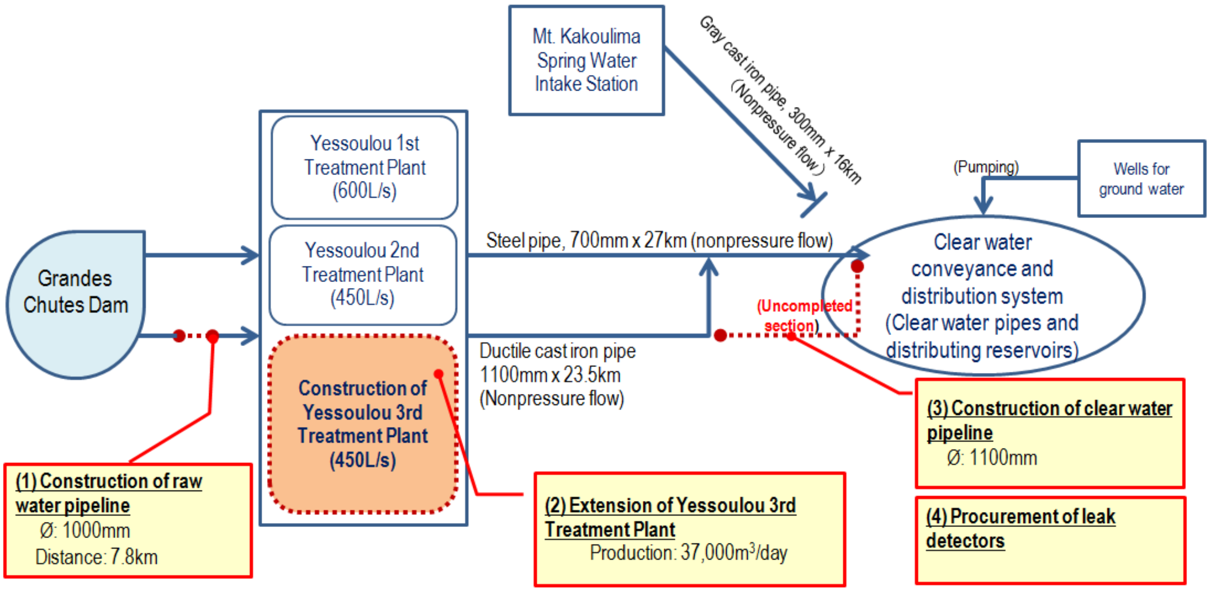
- to complete the pipeline for raw water diameter to 1,000 mm between *Grande chute* (great falls) to Yessoulou of 8 km,
- the construction of a third water station with a capacity of 37,000 m^3/day,
- to have more water storage tanks at Sonfonia and Cimenterie and
- the complement of the water conveying pipe treated diameter of 1,100 mm on 3.5 km. (Kaneko M, 2012)



Schema 3: Schematic drawing of raw water pipes, Treated water pipes and a portion of distribution basins

Source: SEG (2009)

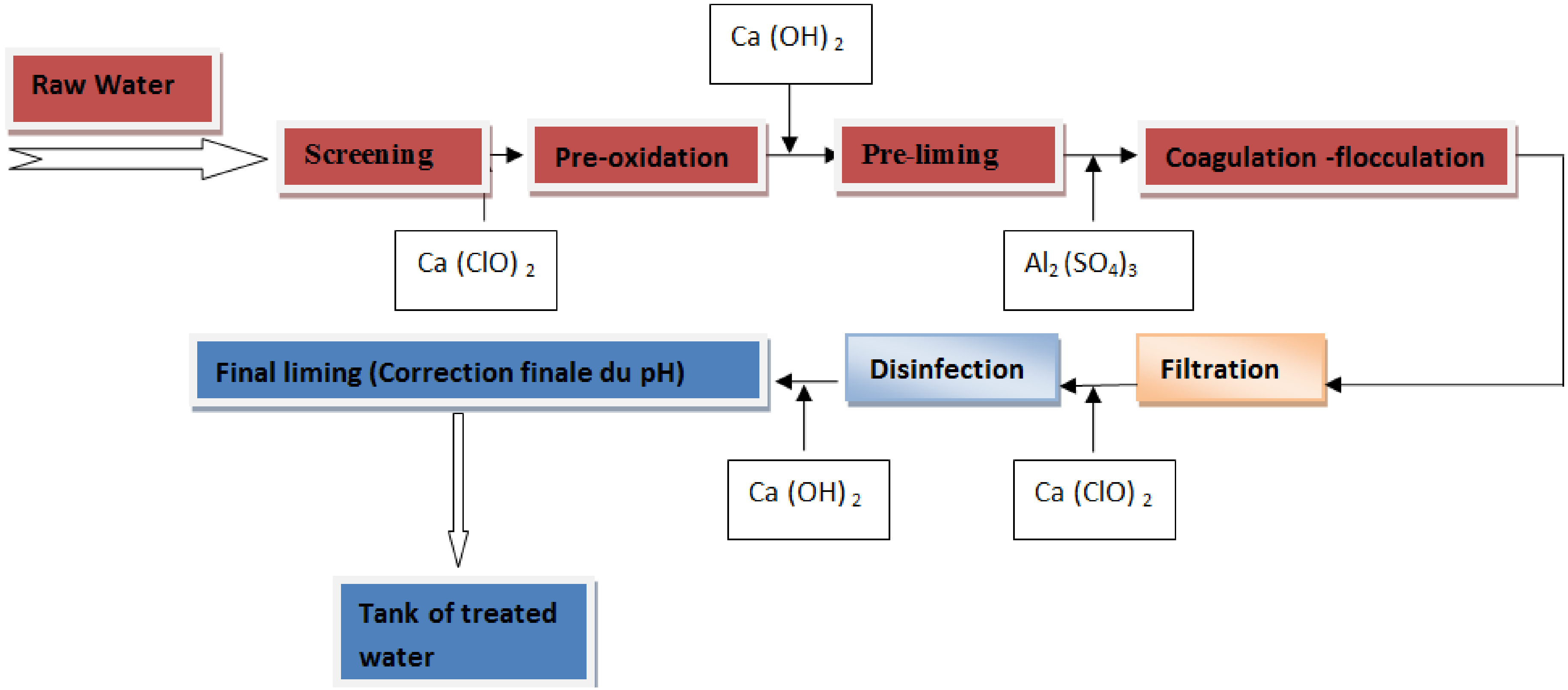
The output of the project as we can see in schema 4 was positive on many aspects, such as the improvement of the quantity and quality (even if more improvement can still be added); which increased the access to safe and drinkable water for the population living in Conakry (World Bank, 2006).



Schema 4: Output of the project - Conceptual diagram of the raw water/Treated water pipelines and contents of support provided by the project

Source: SEG (2009)

Yessoulou 2 and 3: Capacity of production 77760 m^3 per day



Schema 5: Description of the drinking water treatment for Yessoulou 2 and 3

Source: SEG (2015)

The second and third water treatment plant construction in Yessoulou (schema 5), have a shorter cycle as the stage of settling was cancelled, and now from the coagulation stage, the water goes directly to the filtration stage. This change does not really help on the quality level, because it makes the stage of filtration longer and more difficult. By skipping the settling step, more particles which were supposed to be kept there will continue to the filtration stage. That will give the particles a high probability of ending up in the cleaned water. This causes diseases.

Raw water:

The raw water comes from the large drop of Kindia named Grandes chutes dam (see image below). Grandes chutes are located 222meters above sea level, allowing gravitation to the water treatment plant without the need for energy.

Figure 3: The Grande chute

Source: Zeidan (2010)

Figure 4: Raw water in Yessoulou

Source: Author (2016)

Screening:

This stage is the stage of pre-treatment. It consists of initials removal of the larger solid contaminants that could interfere in the treatment process and even damage the equipment; for instance wood, plastics, papers etc.

Figure 5: Screening process

Source: SIAM (2012)

Pre-oxidation:

This phase is used to oxidize the organic load to decrease, such as oxidal minerals and some mineral element. This step is made in advance to allow filters to breath. After oxidation, the colour changes, that is also one of the reason that it is done at the early stages. Also, allowing maintenance of the health standard decanters. The product used by the Yessoulou plants which help realize this operation is the Calcium hypochlorite - $Ca(ClO)_2$.

Figure 6: Ca (ClO) 2 tanks

Source: Author (2016)

Pre-liming:

With the Calcium hydroxide Ca $(OH)_2$, we try to correct the pH. That is done by mineralizing the water, which will help optimize the coagulation and flocculation. The pH should be around 7 to maintain the level of Aluminium sulphate - $Al_2(SO_4)_3$ which happen to be one of the men element of the coagulation.

Figure 7: Ca (OH) 2 solution making process in Yessoulou

Source: Author (2016)

Figure 8: Device used to measure the quantity of Ca (OH) 2 called "Doseuse"

Source: Author (2016)

Coagulation:

After adding the Aluminium sulphate - $Al_2 (SO_4)_3$ to the water, all small colloidal particles that do not tend to settle or sediment gathers. We can consider the coagulation process as the destabilizer of colloids, as it is done by neutralizing the forces. In the water treatment process, the coagulation and flocculation process are complementary. While the coagulation process is used for thickening of solid suspended colloidal particles, the flocculation process is used to form the clumps of solids in a solution, which is called flocs.

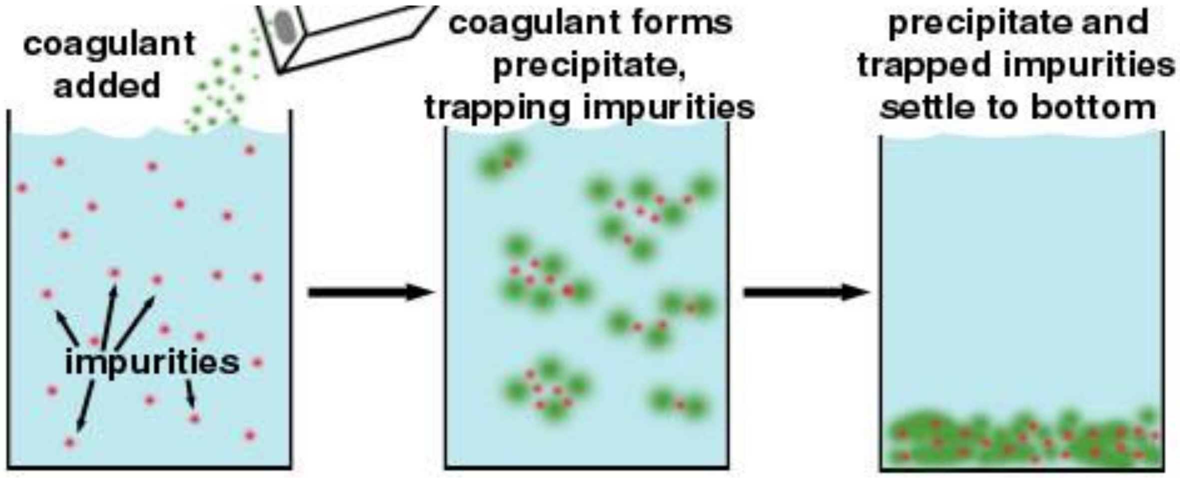


Figure 9: Coagulation process

Source: Casiday , Noelken, Frey (2008)

Flocculation:

The flocculation is a physical and chemical operation which brings together small particles to form larger ones called "flakes". It can be done by adding some flocculating agent or by agitation. As it is a follow up of the coagulation process, the particles formed during the coagulation are now mixed with the flocculent. The mixed blade is the one used for the mixture in the flocculation basin to make the flocs; which will then allow the settlement in the sedimentation basin and the remaining is then removed by the filter.

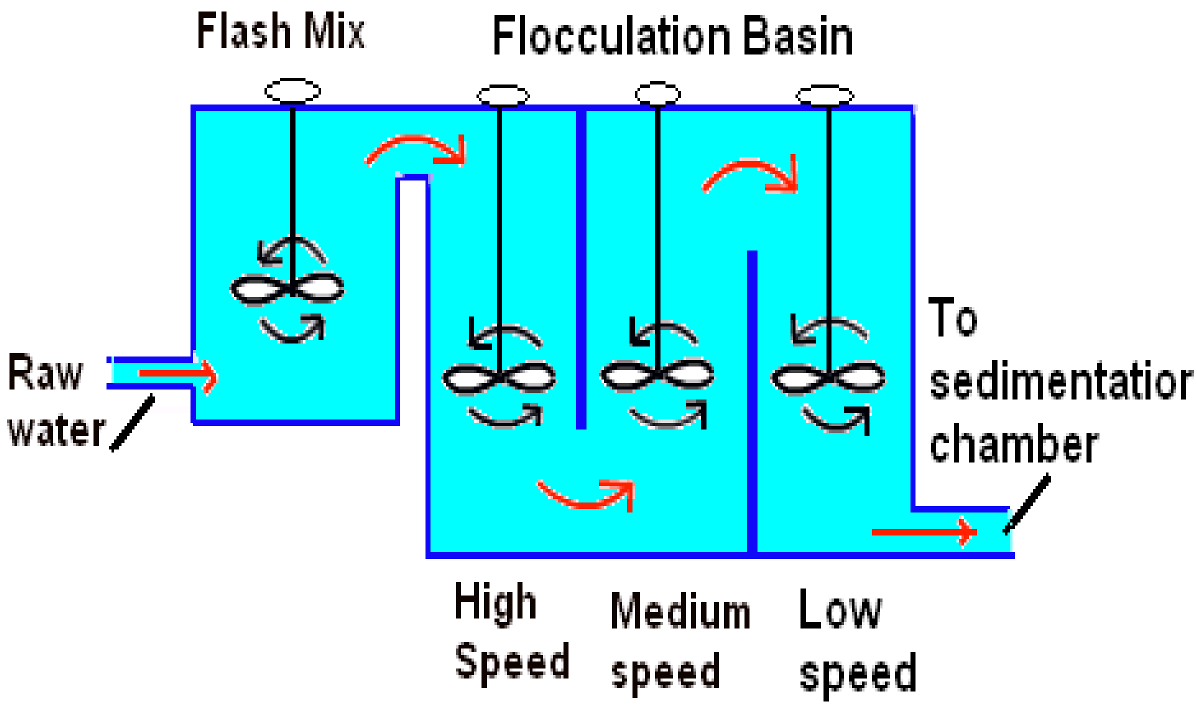


Figure 10: Flocculation process

Source: Pearson (2016)

Figure 11: Flocculation process in Yessoulou

Source: Author (2016)

Settling (Decantation):

The decantation process allows elimination of a high percentage of impurities. It consists in separating the solids (the flocs which were formed during the previous processes and are not thin) from the liquid. The decantation is a facilitator process for the filtration. In Yessoulou it is done in a big basin similar to the one used for filtration.

This stage is used only in the plant of Yessoulou1 and due to some economic reason it was cancelled in the latest project implemented (Yessoulou 2 and 3).

Figure 12: Settling (Decantation) process in Yessoulou

Source: Author (2016)

Filtration:

Filtration is the final stage of the water clarification process in the purification cycle; it aims to improve the organoleptic of drinking water in health aspects. Also aims to eliminate worms, microorganisms and their cysts on health grounds. The health aspect is completed by the removal of organic matter that may react with disinfectants and cause the formation of carcinogenic compounds. The elimination of this suspended organic matter also contributes to the removal of water coloration and therefore of a san organoleptic character (Alley E, 2007).

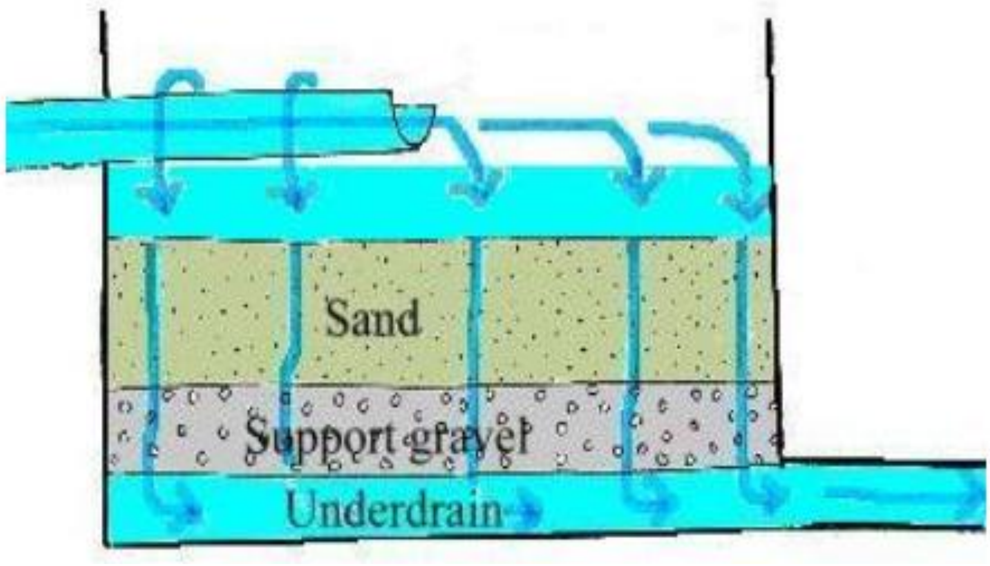


Figure 13: Filtration process

Source: SEG (2009)

Figure 14: Rapid Filtration in the Yessoulou Plant

Source: Author (2016)

Disinfection:

The disinfection process is a process where we eliminate or deactivate the microorganism pathogens. After this stage, the water can be directed to the tank of treated water where there is no need to correct the pH level of the water. But if needed, it goes through the final liming stage.

Final liming: This stage help calibrate the pH of the water; that means if after the disinfection the pH of the water is still not according to the standard, we can add the Calcium hydroxide $Ca(OH)_2$ to correct it.

This stage is needed, because of the pH level correcting. In Yessoulou, we do not do anything after this stage and then, the water goes directly to the tank of treated water (where the water is store before the distribution to the reservoir in the capital city Conakry).

Sterilization: it is the systematic elimination of the pathogenic and not pathogenic microorganism. It is done with the gas of chlorine when the water exits Yessoulou for the tank in Conakry.

2. Aims of the thesis

The goal of the research was to design an auxiliary water purification unit in Yessoulou to help with the improvement of the quality of water deserved in the capital town Conakry. The research was focused on a proposition of a design of suitable auxiliary water purification unit based on the data obtained from the SEG and also from our water samples.

Main objective:

The main objective of this case study was to propose a design of an auxiliary water purification unit in Yessoulou to improve the quality up the standard of accessible drinkable water in the capital town Conakry.

Specific objective:

The specific objective was to analyse the quality of the actual treated water, find the critical points, which will then help propose an advance water purification technology suitable for the unit.

3. Material and methods

The thesis was structured in the following way. The first part deals with the collection of samples and data related to the water treatment unit “Yessoulou” for the water supply for Conakry, also an overview of scientific professional papers, articles in Web of Sciences, Guinea SEG national reports. The second part deals with the analyses, practical evaluation base on primary data collection (water sampling and other primary data) and data processing. The third part provides a final design of the auxiliary water treatment unit Yessoulou.

A map of the study area was drawn and sample points have clearly been shown on Figure 12. Samples were been collected on 6 different points which were used for analysis. Each of the samples represents a particular stage of the treatment plant. At each of these points, measurement of the physical, biological and chemical parameters were conducted. Some parameters like the acidity (pH), total dissolve solids (TDS), suspended solids (TSS), electrical conductivity (EC), temperature, fecal coliform, total coliform, total chlorine, free chlorine and other were measured.

3.1 Study area

The study was focused on the water supply of Conakry which is the capital of Guinea. Conakry, even though is located on a peninsula struggles with unavailability of drinkable water.

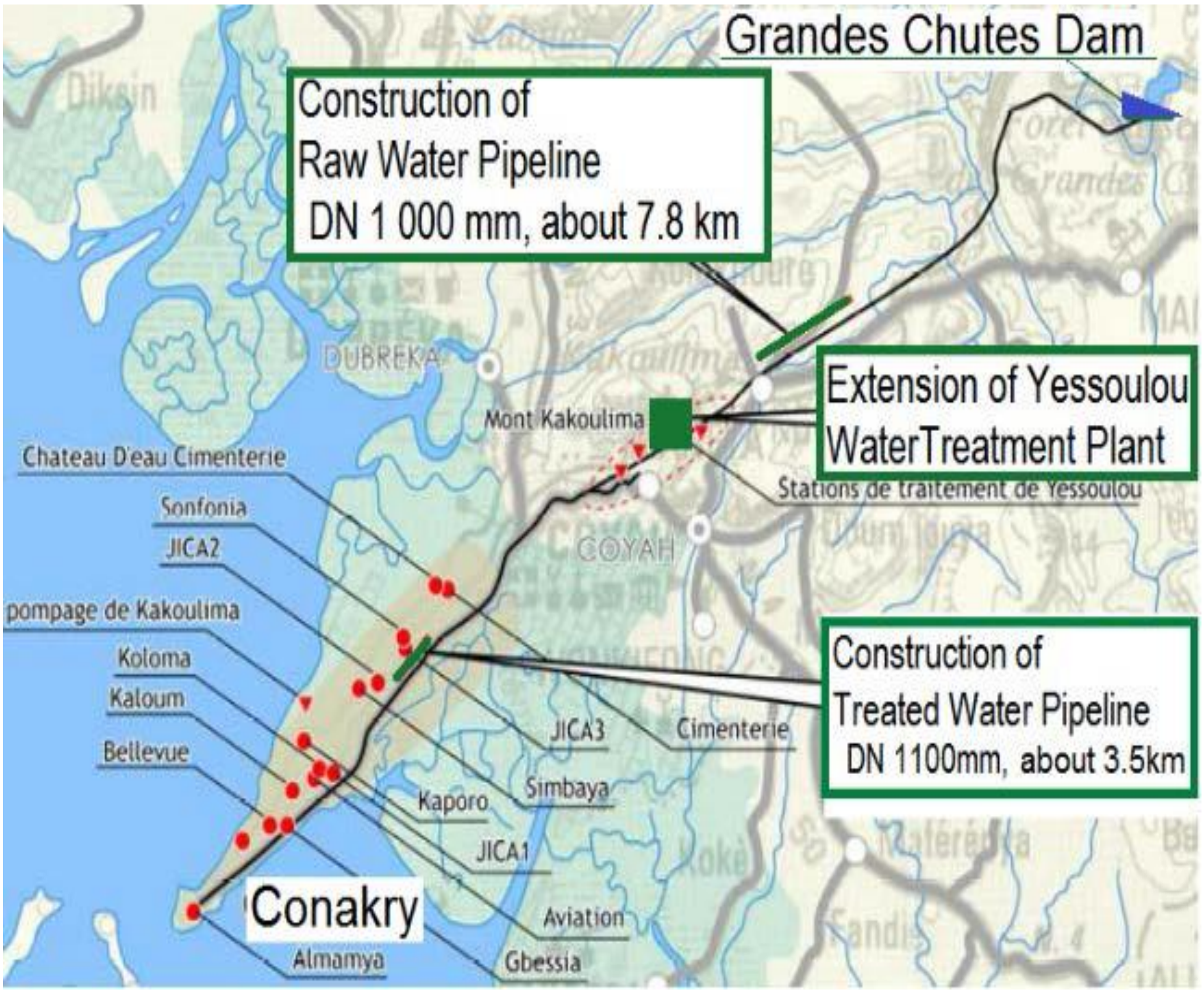


Figure 15: The map of Conakry

Source: Kaneko (2012)

The largest production facilities of water, addictions and primary distribution infrastructure for Conakry was developed during the first, second and third water projects in the years 1960, 1990 and 2000. 85% of the water supplied in Conakry comes from the processing plant of Yessoulou, which is fed with row water by the *Grandes Chutes* (great falls) located about 80 km from the city. The rest of the water supplies come from other surface resources (Lake Sonfonia, catchments Kakoulima) not to forget the 7 drilling sites in the urban area. The 24 centres in the rural areas are powered by 66% of groundwater and 34% of under groundwater.

In the year 2002, after the implementation of the 2 first projects and a total population of 1,632,868 in Conakry, the access to drinking water had improved to 73% (SEG, 2015)

Table 2: Water Production by SEG for Conakry and calculation of water shortage

Water source	Water production in 2012
Grandes Chutes Dam (Yessoulou Water Treatment Plant)	123,000 m3/day
Lake Sonfonia (Sonfonia Water Treatment Plant)	10,000 m3/day
Kakoulima Spring	5,700 m3/day
Groundwater	25,300 m3/day
(1) Maximum water production by SEG	164,000 m3/day
(2) Required water quantity (PK0-PK50)	286,000 m3/day
(3) Shortage (1)-(2)	▲122,000 m3/day

Source: Kaneko (2012)

The figures in table 2 show that there was a lot of progress during the years with the produce quantity of water. As the urban population is rapidly increasing therefore the required water quantity was still far to be reached. It still remains a challenge to cover the water needs of the population. People moving from the rural areas to the urban one, accelerated the increase of the urban population, which leads to the increase of the need of water. That was one of the main reasons for the focus being more on the quantity than the quality of the water produced.

As mentioned in the table 2, Yessoulou by itself produce the majority (123,000 m^3/ day) of the capital Conakry supplied water, although the quantity is large, the quality still remains an issue. Table 3 shows that the newest plant (2 and 3) produce less than the first one if taken individually. The reason behind was that the quality was supposed to be better.

Table 3: Water Production at each Yessoulou Water Treatment Plant

Indicator	Produced Water
Water production at Yessoulou Water Treatment plant	1st plant: 49,000 m^3/day 2nd plant: 37,000 m^3/day 3rd plant: 37,000 m^3/day Total: 123,000 m^3/day

Source: Kaneko (2012)

3.2 Some measurements techniques

3.2.1 Measurement of temperature

Temperature is the degree of hotness or coldness of a body, a place or an object. The instrument used to measure the temperature was the thermometer, and it is being measure in degree Celsius (°C) or degree Fahrenheit (°F). It was always necessary to measure the temperature and the electrical conductivity (EC) at the same time, because temperature affects the EC and different kinds of solubility.

A digital thermometer was used to measure the temperature on the field where:

- Immersed the thermometer in the sample,
- waited for some minutes for the temperature readings to equilibrate,
- then read and recorded the temperature while the thermometer was immersed in the water sample,
- recorded the readings,
- switch off the thermometer,
- Cleaned it by using a dry cloth and kept it for further use on the other sample points.

3.2.2 Measurement of Hydrogen ions concentration (pH)

PH is a measurement of the hydrogen ion concentration in a solution. It is a very important parameter as it shows the level of acidity or alkalinity of the water. It also gives us the information about a potential contamination, which is what makes it a vital parameter.

A pH meter was used to measure the acidity and alkalinity level of the samples collected at each sample point. The measurement was done as follows:

- Collect water at each sample point using a clean container,
- carry the samples to the lab and let the water sit for a while to allow it to stabilize,
- calibrate the pH meter by testing it in a substance that it has a known pH rating,
- measure the temperature with a thermometer,
- adjust the pH meter to match the sample temperature,
- immense the probe of pH meter into the water sample,
- wait for the meter to come to equilibrium,
- record the readings on the pH meter.

3.2.3 Measurement of the total suspended solids (TSS)

The solids are divided into suspended solids (all particles lager than 2 microns) and dissolved ones (anything smaller than 2 microns).

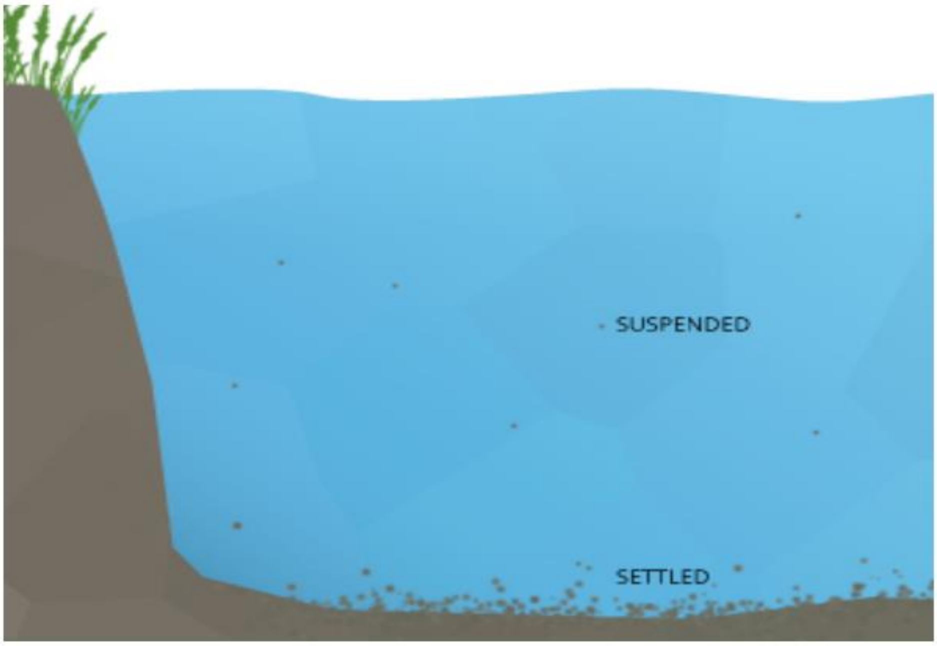


Figure 16: Suspended solids

Source: Fondriest Environmental Inc (2015)

The TSS concentration include both organic and inorganic particles of all size; for instance anything drifting or floating in the water, from sediment, silt, algae, sand to plankton, organic particles from decomposing materials and other.

By allowing microorganisms to hide from disinfectants within solid aggregates, the high concentration of suspended solids decreases the effectiveness of drinking water disinfection agent.

The TSS probe has an operating concentration range of 0.001 to 400g/L.

The laboratory TSS method used is the gravimetric procedure where:

- the glass filters should be prepare before sampling, by first soaking them in distilled water, drying them in a 103° C to 104°C oven for 30 minutes, and then weigh and record the weights;
- filter 100 ml of sample trough each pre-weighed filter;

- dry the filter in a 103° C to 104°C oven for an hour, then cool it to the room temperature, and weigh it again;
- the previous step continues until the fibre reaches a constant weight, then we record the end weight;
- the increase in weight represents TSS. Calculate TSS by using the equation below.

  TSS (mg/L) = ([A-B]*1000)/C

  Where A = End weight of the filter in g

  B = Initial weight of the filter in g

  C = Volume of water filtered in L

3.1.4 Turbidity

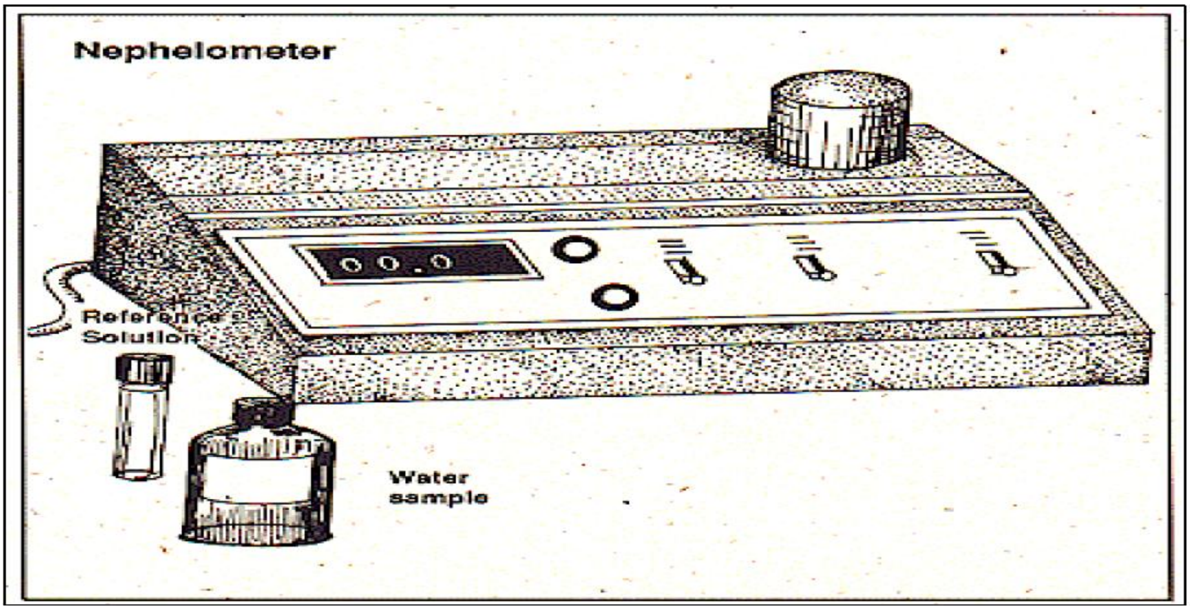


Figure 17: Nephelometer instrument using to detect Total suspended solids.

Souce: Nazir (2015)

Turbidity is a measurement of the degree of water clarity. And as an optical property of water, it measures the amount of light that is absorbed and scattered by particles in the water samples. The easiest ways to measure the turbidity is to either use a Nephelometer or Jackson turbid meter to compare a reference solution to the sample. Unlike TSS measurement, the turbidity measurement does not include any settled solids or bedload, also no need for sample preparation, except shaking the sample bottle well before the analysis.

Even though turbidity and total suspended solids often overlap, there are a few outlying factors that only contribute to one or the other.

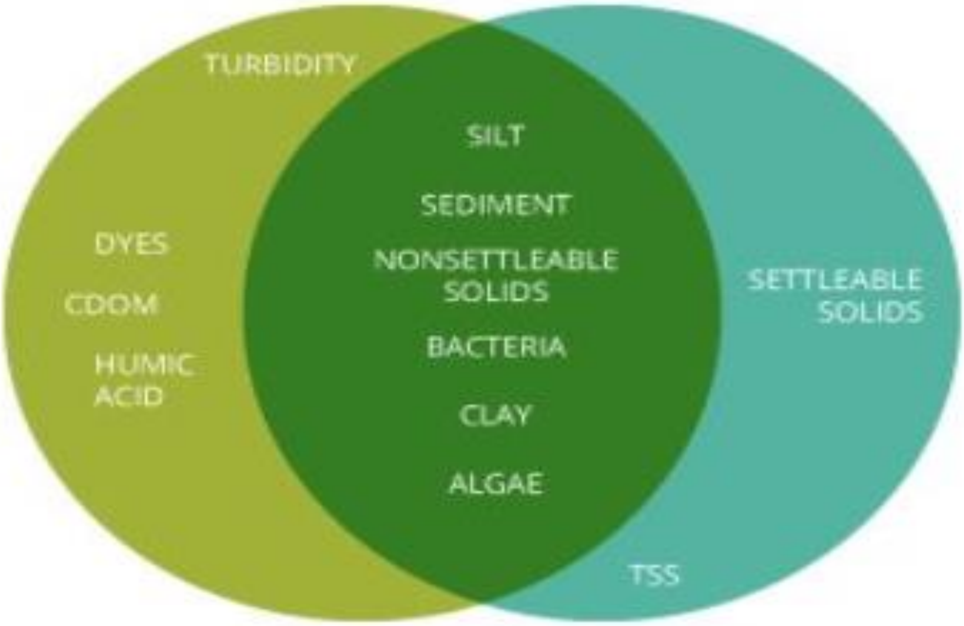


Figure 18: Turbidity vs suspended solids

Source: FONDRIEST ENVIRONMENTAL INC, 2015

As stipulated by the British Columbia (1998), the suspended soil particles make water turbid and unpleasant to drink, and increase water treatment requirements.

4. Results

4.1 Analysis of collected data

Table 4 below shows the analysis evaluation of the raw water influent to the treatment plants and analysis of water flowing from the treatment plant to the grid - compared with the norm (the standard required).

Table 5 shows the results from samples which were collected on the domestic level, considering that there are 80 km between the Yessoulou plant and Conakry the capital city.

From these two tables, we found that there are any visible changes on the water treated parameter from the exit point (Yessoulou) to the consumer point (Conakry – capital city).

In the table No. 4 are stated:

- Average values of individual investigated parameters pollution of raw water,
- the maximum values of pollution by individual investigated parameters of raw water,
- means parameters pollution for water treatment when entering distribution,
- limits tent State GUINEA if no rate then there is the EU standards.

In the table No. 5 are stated:

- Parameters of three distributions points,chosen randomly in the capital city Conakry,
- limits tent State GUINEA if no rate then there is the EU standards.

The technology of water treatment plant was designed and supplied by the French company Veolia in the 80-ies on the flow capacity of 100 000 m3 / day and at present is about 22% permanent overloaded.

This affects the efficiency and effectiveness of the treatment process, such as the following:

- **Mixing processes**: application of chemicals to the process (shorter exposure time, insufficient homogenization of substances

- **Aeration**: the smaller the saturation ulcer oxygen (O_2)

- **Stamping processes**: small residence time in the process - less effective

- **Coagulation processes**: the lack of homogenization with the coagulant and the short time of floc formation

- **Settling processes**: rimmed flow, short-term effects of gravity, discharging flakes to filter

- Overloading filters flakes need frequent washing, energy intensity and plotting turbidity in treated water also higher levels in drinking water.

Table 4: Summary results of the analysis

Parameter	unit	Raw water, average	Raw water, maximum	exit water treatment	guarantee value (standard)
Flow	m^3/h	123	128		
Temperature	°C	25,4	29,97	23-27	25
Conductivity at 25°C	µS/cm	1O,9	50	110*	200 -1100
pH at 25°C		6,6	7,58	7,5	6,5-9
Turbidity	NTU	4,18	10	1,8 -5*	2
Suspended solids	mg/l	0,64	10,3	7-9*	8
Dry rest at 105°C	mg/l				
TDS	mg/l	5,45	25	30*	300
Hardness	mmol/l	0,99	4,39	>2	200
KNK8,3 (p-alkalinity)	mmol/l				
KNK4,5 (m-alkalinity)	mmol/l				
SiO2 (photomeric)	mg/l				
COD Mn	mg o2/l	2,8	8	3,2	3
TOC	mg/l				
Fe tot.	mg/l	0,055	0,179	<0,1	0,3
Mn	mg/l	0,036	0,091	<0,2	0,2
Ca^{2+}	mg/l	0,51	2,63	30*	100
Mg^{2+}	mg/l	0,48	1,76	<1	50
Na^+	mg/l				
K^+	mg/l				
Cl^-	mg/l	0,28	0,63	<250	250
SO_4^{2-}	mg/l	5,14	8,09	<250	250
NO_3^-	mg/l	0,052	2,86	<10	50
NH_4^-	mg/l	0,99	2,3	0,7	0,5
HCO_3^-	mg/l				
CO_3^{2-}	mg/l				

Ba^{2+}	mg/l				
Sr^{2+}	mg/l				
Al tot.	mg/l	0,147	0,252	<0,2	0,2
Total coliform	UFC	46	58	18-23	20
Fecal coliform	UFC	28	37	2	0

Source: Author (2016) and SEG (2015)

Note:

Red value= value above the threshold standards for drinking water at the outlet of the water treatment plant

* Values influenced by technology

At the sight of its results, we can notice that there are still things to fix in the current processing of water treatment system, because the standards are not respected as they should.

Table 5: Summary results of sample from domestic level analyses

Parameters	Domestic level				**Norma**
	Unite	**Almamya**	**Sig madina**	**Koloma**	
Temperature	°C	26.8	25.3	26.3	8,0-12,0
pH		6.6	6.7	7.55	6,5 - 9,5
Suspended solids (TSS)	mg/l	<1	<1	<1	5
Conductivity	µS/cm	38.45	50	19.1	125
TDS	mg/l	19.2	25	8.55	250
Fecal coliform	UFC	<1	<1	2	0
Total coliform	UFC	9	6	15	20
Color	mg/IPtCo	4	6	1	20
Turbidity	NTU	1.05	1.05	0.96	5
Total chlorine	mg/l	0.15	0.18	0.2	2
Free chlorine	mg/l	0.1	0.11	0.12	0.3

Source: Author (2016)

Excess indicator in drinking water

Temperature: 23 - 27°C standard 25°C (EU 8 - 12°C), this parameter in term of geographic is difficult to be resolve.

From the viewpoint of water management it is unfavourable to the development of bacterial contamination in the distribution, especially in ways of distributing the local frontloading into tank houses. It would be appropriate to add a central reservoir of treated water cooling system; as we can see in the table below the standard temperature is not respected even on domestic level.

Turbidity: 1.8 – 5 NTU standard 2 NTU (EU 5 NTU)

Suspended solid: 7 – 9 mg / l standard 8 mg / l

Both parameters range to a limit for a standard. These parameters are particularly fluctuation in the rainy season, when there is a large increase in turbidity flush humid substances that are partially dissolved, colloids, emulsified in water is a strengthening the coagulation process.

Chemical Oxygen Demand (COD): 3.2 mg / l standard 3 mg / l – a slight increase on the standard is related to the parameters associated with reduced turbidity, lack of oxygen during aeration.

Ammonium NO4 – (ammonium anion): 0,7 mg / l – 0.5 mg / l – modifies the sensory perception of water and is related with turbidity contamination, organic matter and other. That is why it is necessary to reinforce and streamline the aeration – Oxidation.

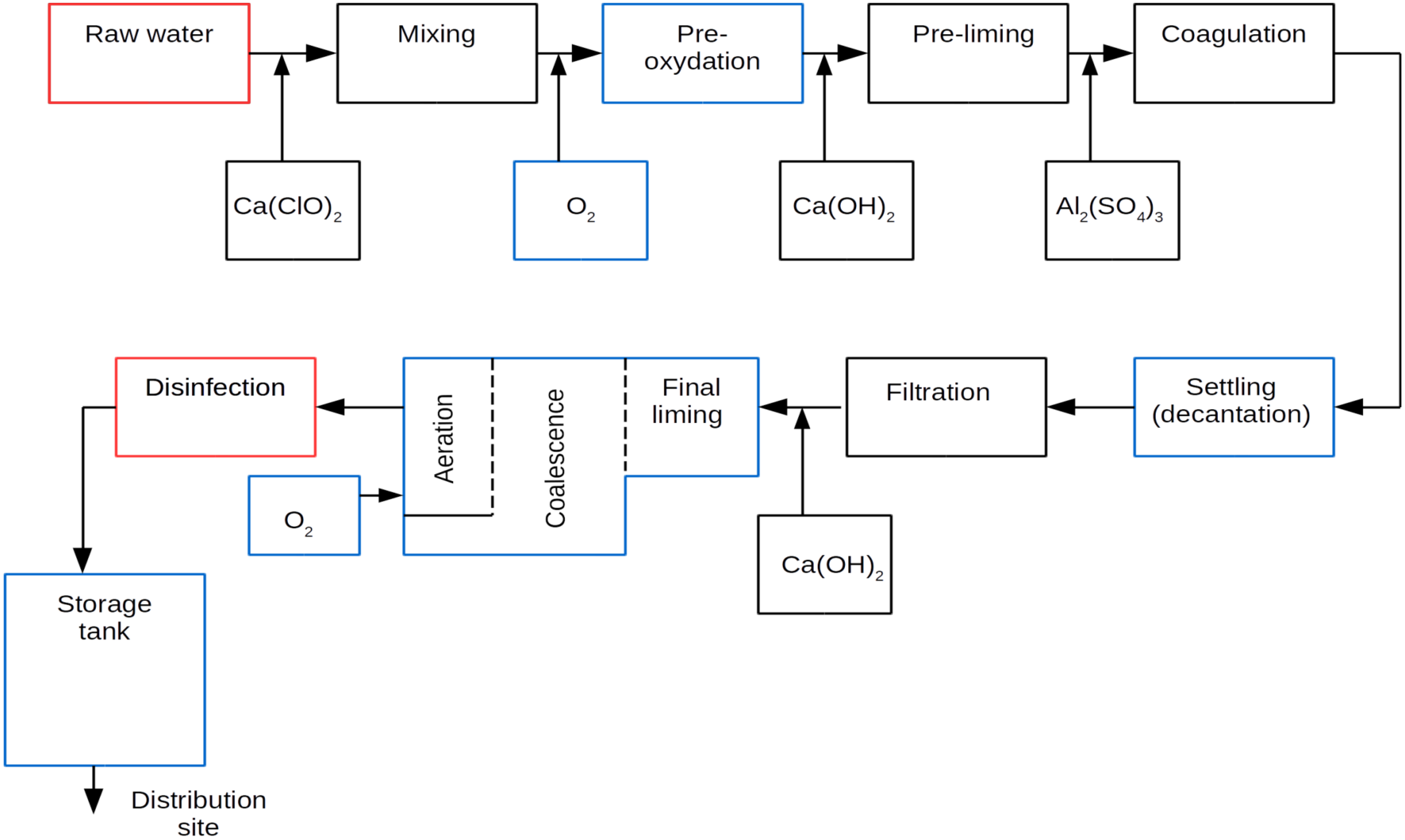
Total coliform: 23 - 18 CFU standard 20 CFU moves to the upper limit and indicates the suitability of the living environment of pathogenic bacteria, it indicates suitability changes disinfectant which may cause bacterial resistance to the action of currently used Calcium hypochlorite - Ca $(CLO)_2$.

Faecal bacteria (Faecal coliform): 2 CFU standards 0 CFU, a very dangerous condition which exceeds the standard.The distribution network of high-temperature water leads to a proliferation of pathogenic bacteria. Dosing disinfectant does not ensure the preservation of water consumption. Indicates changed suitability of disinfectant, which could lead to bacterial resistance of currently used effected Calcium hypochlorite - Ca $(CLO)_2$.

4.2 Proposal of auxiliary water purification unit

4.2.1 The complete design of the proposed auxiliary water purification unit

The proposal from the schema 6 shows 2 mains changes (the one in red), which is going to focus first on improving the quality of raw water (see schema 7), by doing the screening in the lake before the water enters the water treatment plant. Second, at the difference of the current system used, the disinfection stage will be move to the end of the treatment cycle before it goes into the tanks of treated water, and we will use the ASOR module (see schema 8), that will ensure a better quality of treated water.



Schema 6: Auxiliary water purification unit

Source: Author (2016)

4.2.2 Description of the innovative technology water treatment

a) **Electrocoagulation system**: is a device which will be located on the surface of the raw water source (LAKE), about 40 meters before the water intake to the treatment of drinking water. Reactors will be carrying floats under water spaced about five meters and anchored by 1. Scum boards. Baffle is fixed to the opposite shore. A scum board is also the carrier cables - supply electrical current from the generator located on the shore. The second baffle is placed before the inlet of water into the pipe for retention of floating particles and the foam on the surface.

The coagulation effect is to ensure the separation of solids and driven into the lake bottom. This will relieve the steps of the coagulation in water treatment plant, where water significantly will be reduce from turbidity (It is usually trouble colloidal-emulsion with the need for chemical precipitation of calcium hydroxide). Due to the low average conductivity of the water, the distance between the electrodes will be significantly reduced. For more information see Description Electro-technology (schema 6)

b) **MIX (screening) disinfection of raw water Ca (ClO) $_2$ (Calcium hypochlorite)**: inhibition of bacteria in the raw water, and prevention in the water treatment process to avoid the multiplication of pathogenic bacteria from raw water.

c) **Pre-oxidation** (oxidation aeration): resulting in increased oxygen saturation (O_2) main mission is to reduce the ammonium ion content. INNOVATION: Regarding the need for an effective reduction of ammonium ions, it is necessary to improve the process of saturation of oxygen in water (O_2). Exchange of micro air bubble wrap or dynamic ventilation with air vacuum ejector.

d) **Pre-liming:** Ca calcium hydroxide mixture (OH) $_2$ - slaked lime to start the process of clarification - precipitation of substances causing turbidity (cloudiness + TSS). Regarding the technology of end electrocoagulation forehead at the first degree, the process will be less precipitation, and increase the effect of the action while reducing chemical consumption.

e) **Coagulation process:** is invoked by the dosage in the water of the Aluminium sulphate coagulant Al_2 (SO_4) $_3$, bringing together the substances precipitated in the coagulation process flakes and their offset (in step No.6 decantation). Even in the coagulation step, or the presence of electrocautery has been to reduce turbidity, also manages to improve the clarity of the water and reduce the use of chemicals.

f) **Decantation (settling):** used for gravitational separation of coagulation flakes (floating) of the sludge and draining water in the purest fractions to facilitate filtration.

INNOVATION: The water treatment plant is hydraulically overloaded by 22%, which causes the short stay in the separator and allows the escape of finer flakes in the filters. To improve the offset effect, we should add colon wall coalescence; the structure will help coagulated flakes with smaller weight in the mud.

g) Filtration of the water: takes place in the sand filters with controlled thinning filter where the final purification of the water.

h) Final liming (water pH correction): this is where we adjust the final pH dosage by using the milk of lime $Ca(OH)_2$ if needed to obtain the required pH.

INNOVATION: A space for the stabilization tanks to divide the wall coalesces to capture lime remains in suspension.

In the third period to complete the wall of the dam, are mounted aeration technologies to increase saturation in water of oxygen (O_2).

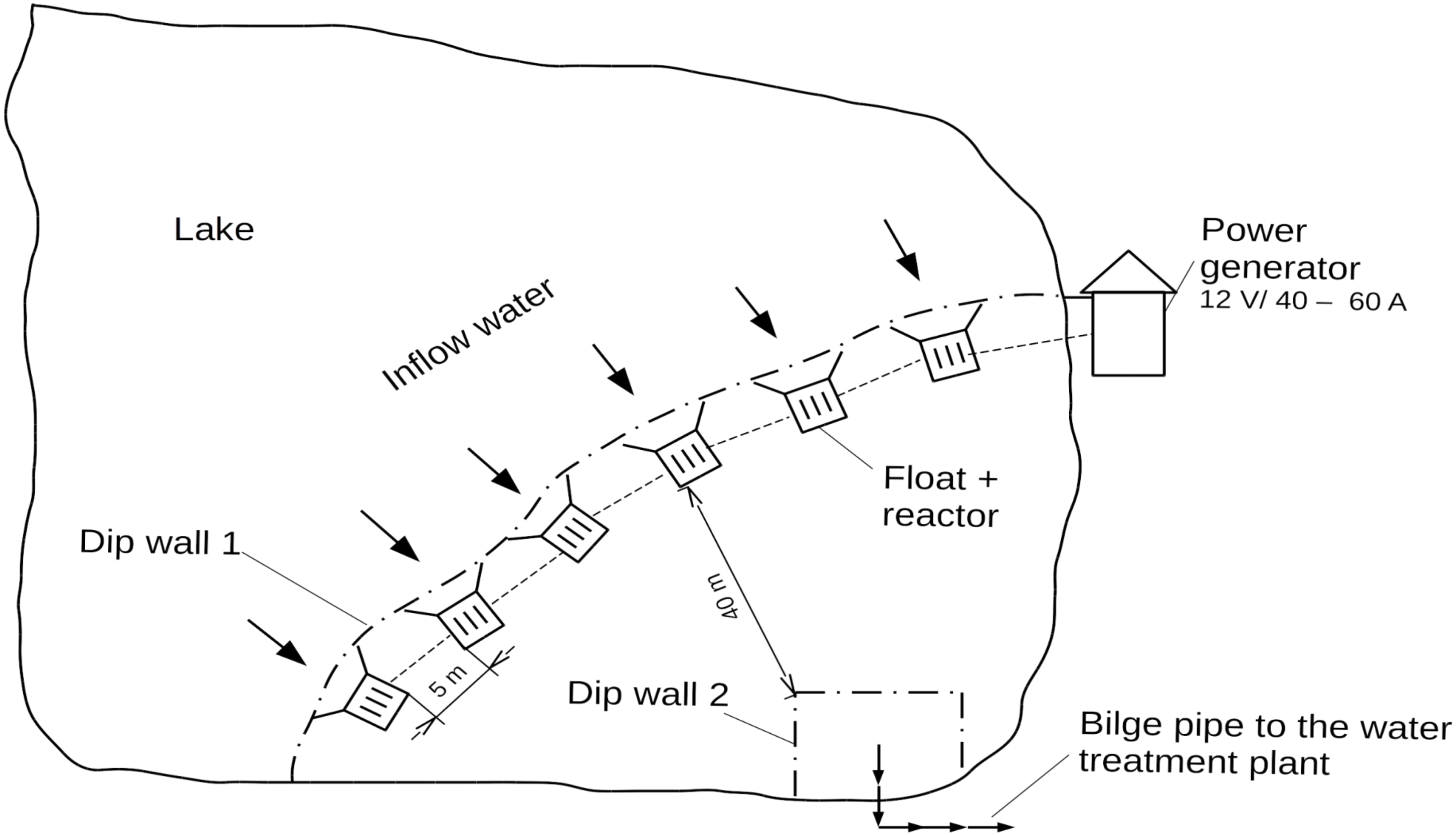
i) The disinfection module: will be move to the last stage, which will be after the final liming not before as the existing cycle.

INNOVATION: Change the disinfectant solution ASOR in which there is bacterial resistance. Site disinfection unit produces NaCl and water solution (see schema 7)

j) **Storage tanks:**

INNOVATION - due to the high temperature of the water, considering the European standard it would be beneficial for the distribution of water and to maintain its quality to cooled water into the tank before distribution at about 12 ° C, inserting the cooling coil. The cooling would be possible to generate a conversion of thermal energy to the coolant.

4.2.3 Description of screening process of the raw water with the electro-coagulation technology before it goes to the water treatment plant



Schema 7: Screening process from the river

Source: Author (2016)

4.2.4 Electrocoagulation technology

Hanging reactor to float - a blue arrow is the direction of flow of water through the reactor

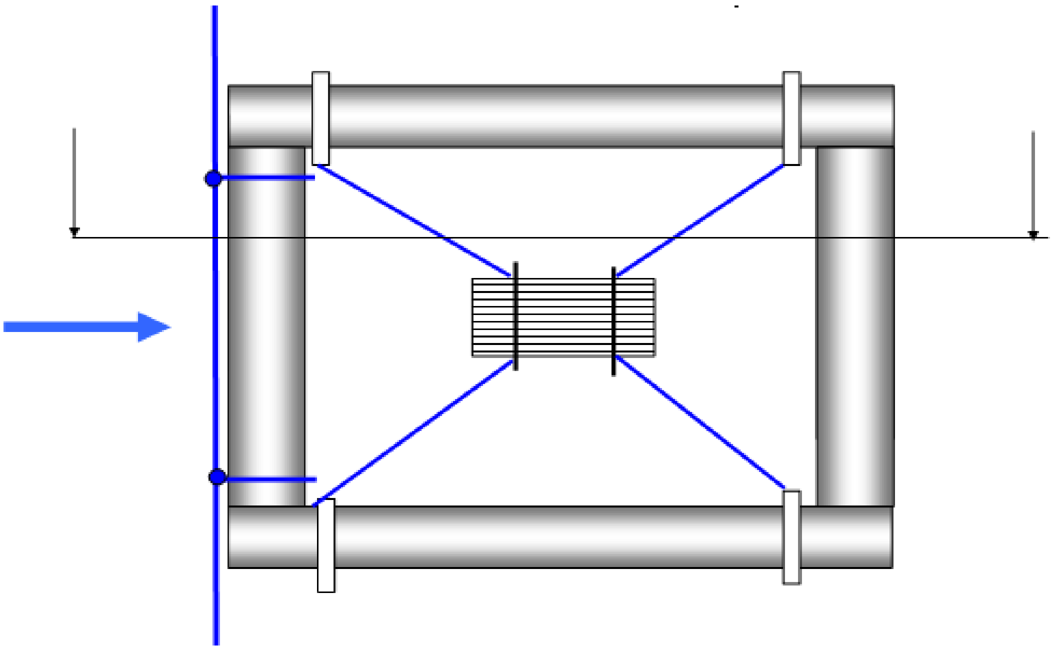


Figure 19: Schematic view of the construction of floats and reactors

The reactor design:

- mutually insulated electrode plates GREEN / PURPLE
- Current generator changed at regular intervals polarity of the electrodes ANODA-GREEN / KATODA – PURPLE to ANODE-purple / KATODA – green

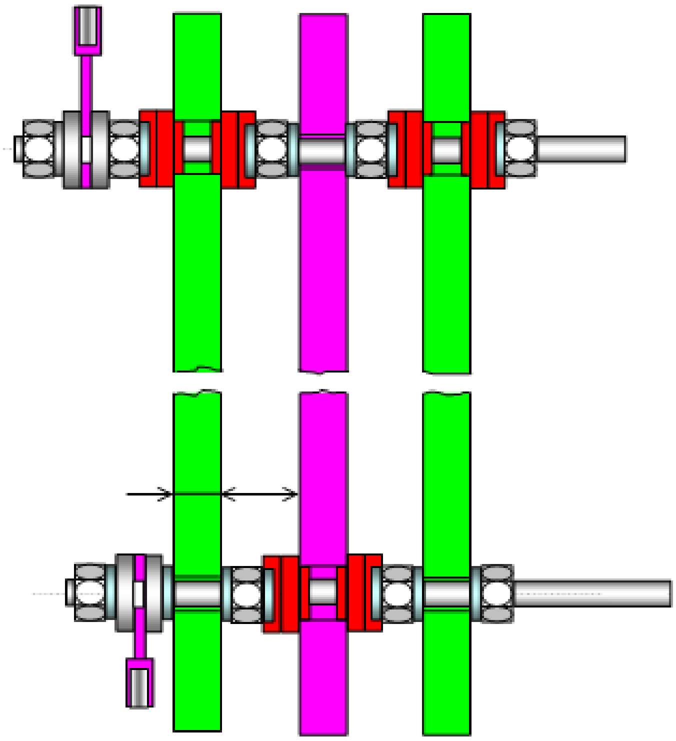


Figure 20: Detail design of the reactor

Technology deployment:

- GRAY BOX - GENERATOR electrocoagulation
- Black line - power supply. current 12V / 60A
- Scum board - serve to anchor buoys; cable carrier; retention on the surface of the floating pollution
- On the blue surface float reactor

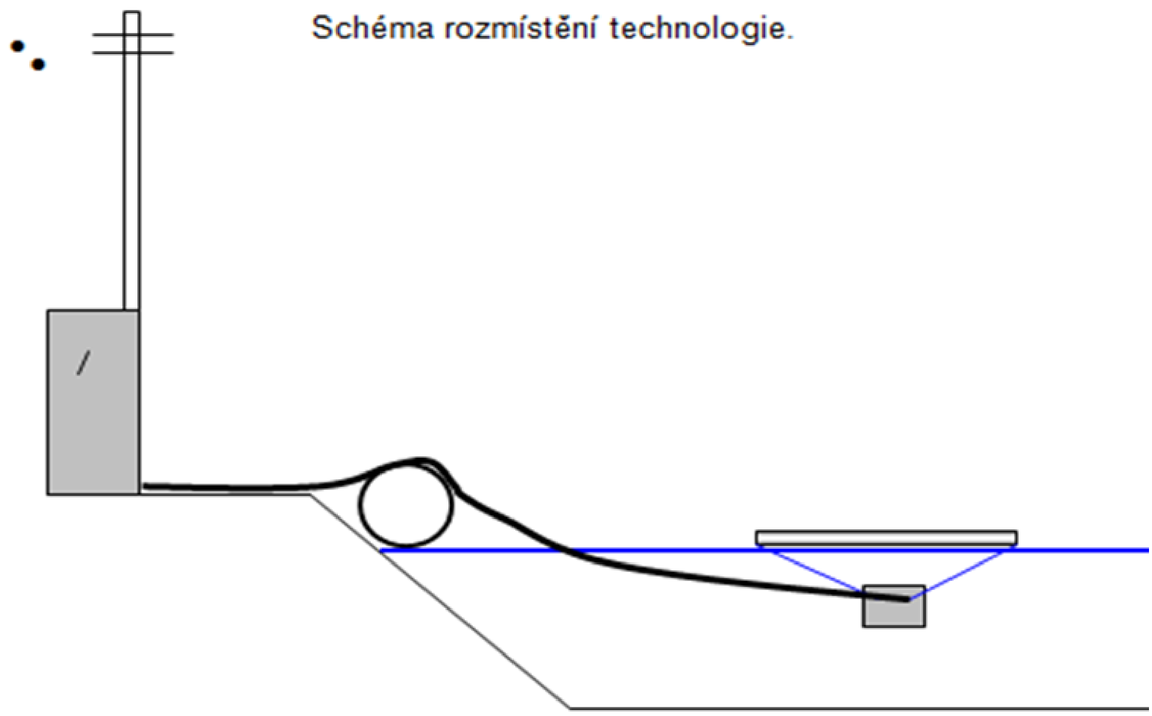


Figure 21: Scheme of the technology arrangement

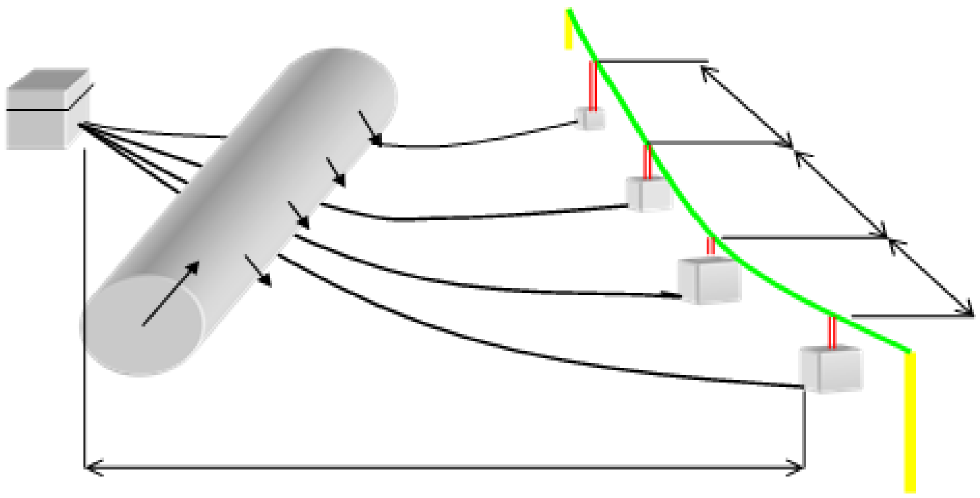


Figure 22: Version of deployment reactors on floats for Scum board

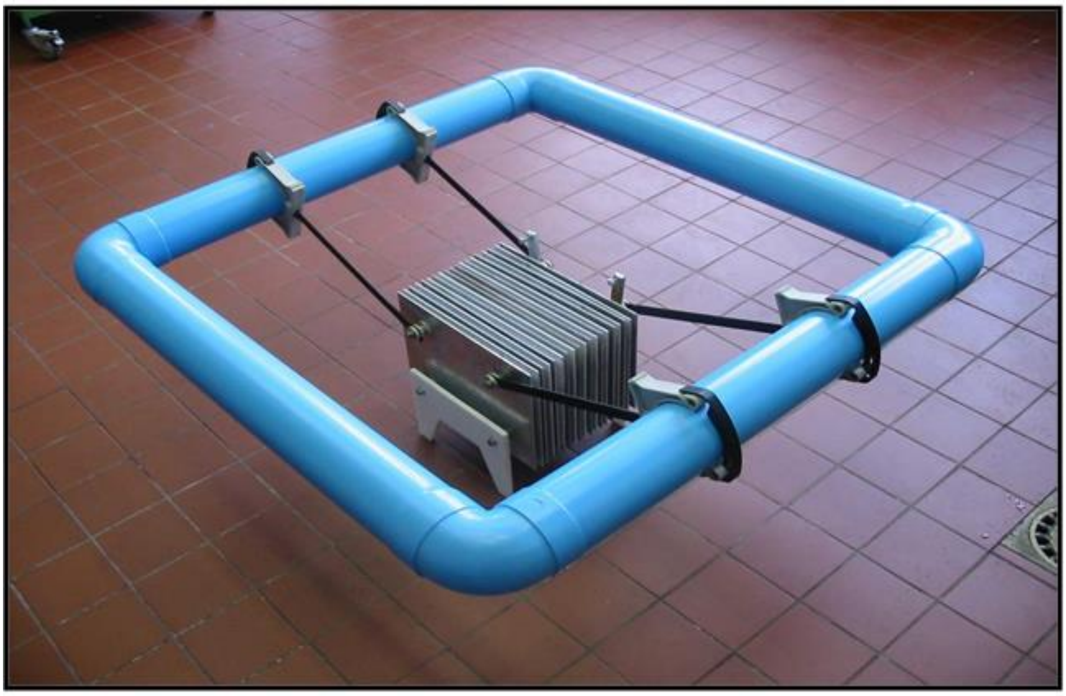


Figure 23: Construction of floats and reactor

Figure 24: Reactor kit / Generator

Figure 25: Electrocoagulation in full operation / loosening coagulation media

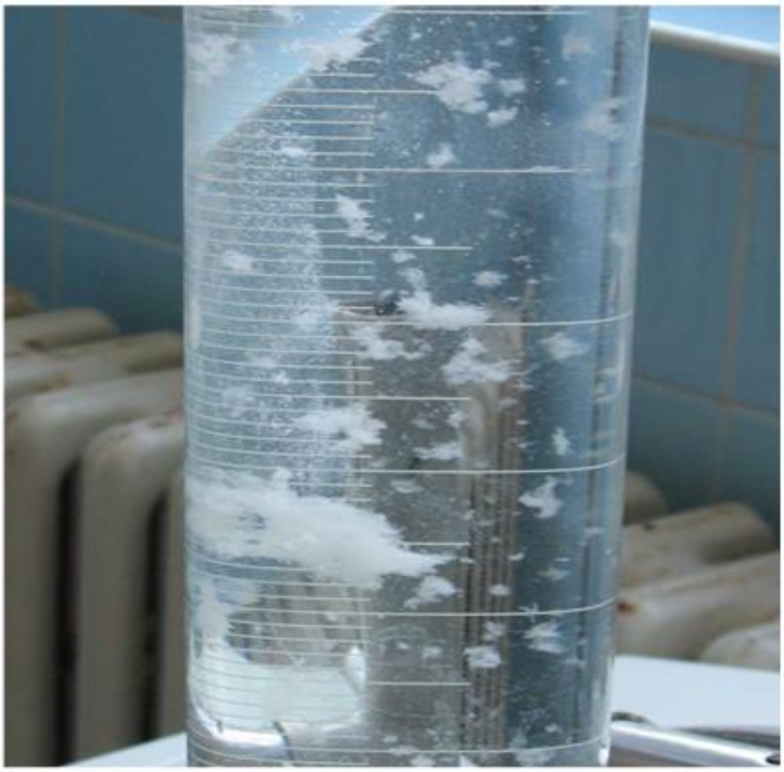
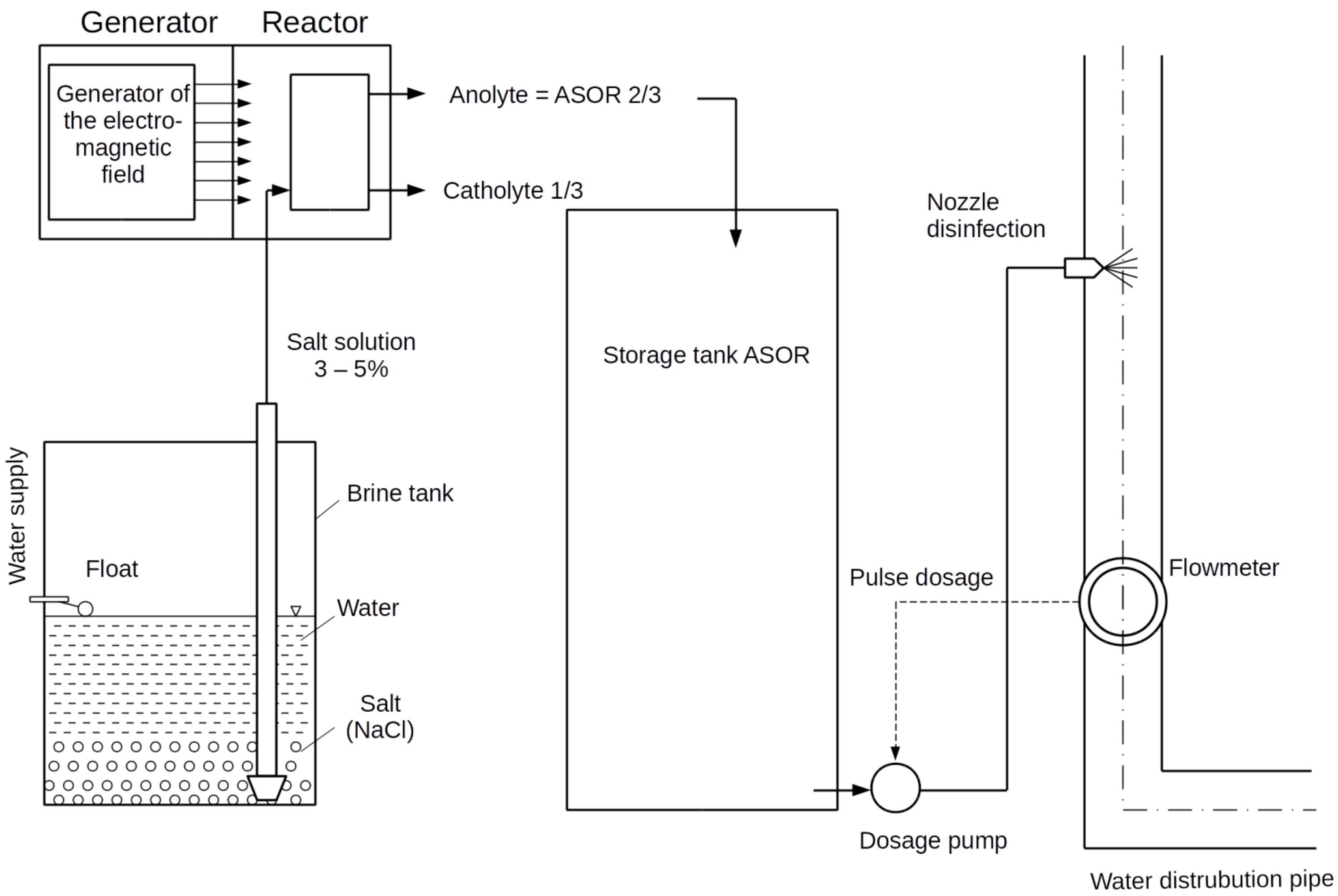


Figure 26: Flocculation and sedimentation

4.2.5. The module for the production of disinfectant solution ASOR

The module in the schema 7 is designed to produce disinfectant solution ASOR mobile units in place of the immediate needs of the disinfectant action, sanitation and water environment. Producing disinfectant solution does not require complex chemical processes and conditions. Source sufficient purified water, salt (NaCl), electric current, that the production costs of one litter of concentrate is very low. It also has less transport costs and less need for a larger storage room. In the production of disinfectant solution ASOR, before the treated water is supply via the waterworks with pressure vessel to the generator module or is supplied from the water main garden hose directly into the generator without the waterworks. Further, brine is inserted into the generator. Brine (saturated with 5% saline NaCl- common salt) is prepared from the pre-treated water and common salt (most commonly in the form of pads or tablets) in a mixer. A disinfectant solution is drained from the generator into a storage container located near the IBC module. Equipment for production of disinfectant solution at the beginning of production is calibrated and then the production process is fully automated. The operator checks only if there is no need to rinse my equipment and output values of pH, redox potential and the chlorine content in the produced resource.



Schema 8: Description of the disinfection module

Source: Author (2016)

ASOR is electrochemically activated salt solution, which utilizes a new approach in the biocidal effect of non-hazardous chemicals. It has wide applications in many sectors of the economy against dangerous pathogens. The big advantage is that there is no resistance to this agent. The product ASOR destroys all microorganisms in a short contact. Think about, bacteria, viruses and after consulting the route of administration as well also mold, fungi including spores.

For a high activity at low concentration of active ingredient and considerate impact on the environment, according to many experts the most acceptable alternative today is still widely used hazardous chemicals. These are also used as the best solution for disinfecting wells and other water sources. Indeed, the use of disinfectant was tested in practice, when in cooperation with humanitarian organizations ADRA and People in Need decontaminated well - the primary source of drinking water for Jesenicko and Novojicinsko during the floods in 2009.

- Disinfectant solution is nontoxic, non-irritating, does not create resistance.
- It is fully biodegradable and is not environmentally hazardous.
- The optimal use to the contamination of drinking water and for the surface decontamination of places expected the bacterial contamination

List of the module equipment

- Generator disinfectant solution

- 2x IBC on volume of 1000 litters

- Mixing device for the preparation of brine

- Tray table salt

- Power generator

- Water tower

- Submersible transport pump

- Hoses with connecting elements

- Wiring with electricity

- Suitcase with tools

- Canister with HCl to flush the chamber with lockable drawer for documents

Distribution of disinfectant solution ASOR:

- Remove the solution from the supply container to be reused to transport containers with a peristaltic pump or by gravity through the delivery valve.
- Using a dosing pump to add the disinfectant solution into existing reservoirs for drinking water in the water system.
- Using a peristaltic pump and DOSATRON (Evaluative dosing) dispenser disinfectant solution to the existing water distribution pipe system.

Table 6: Technical parameters of the module for the production of disinfectant solution

The maximum amount of the produced liquid disinfectant	100 l/1h.
Required input module	6,5 kWh
The consumption of salt for the manufacture of 1 m3 disinfectant solution	10 kg
Water consumption for production of 1 m3 disinfectant solution	1,4 m^3
Required water pressure at the input to the system - minimum	2 bar
The area required for placement of the container incl. handling space	8,2 m^2
The weight of the container - for transport	270kg
External dimensions of the container D / V / W [mm]	1600/1850/700

Figure 27: General view - a module for the production of disinfectant Vert Esprit

Source: PROTE LTD (2015)

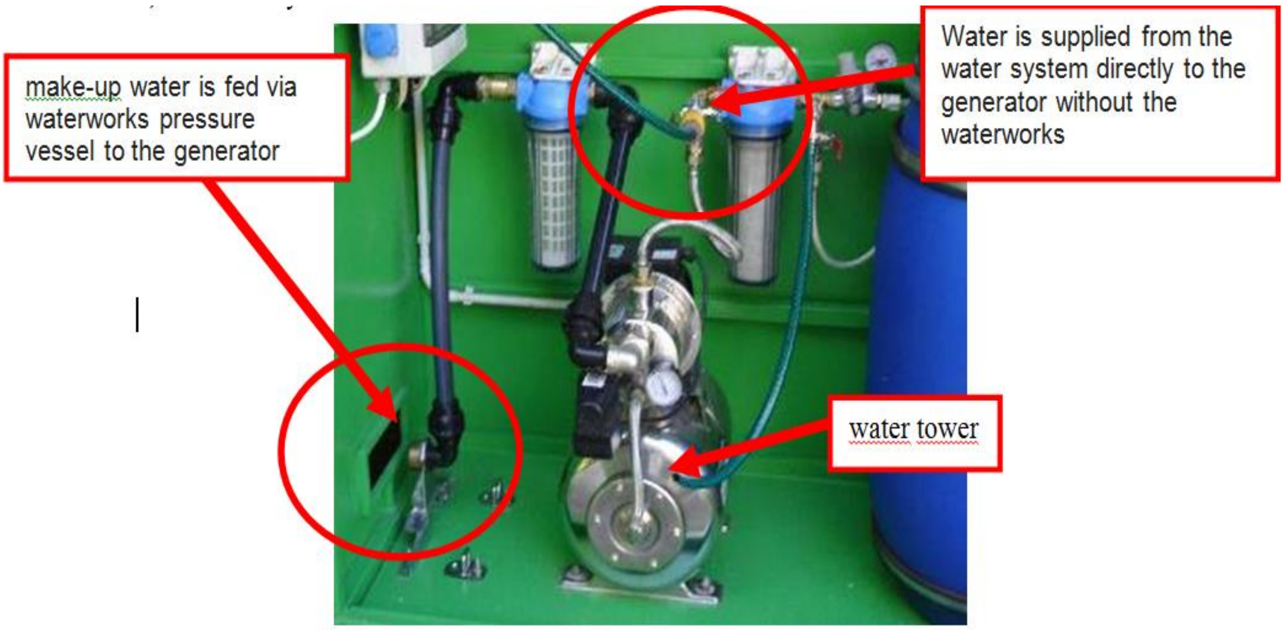


Figure 28: The water supply to the module

Source: PROTE LTD (2015)

Figure 29: Reservoir brine tank HCl

Source: PROTE LTD (2015)

Figure 30: Generator control panel

Source: PROTE LTD (2015)

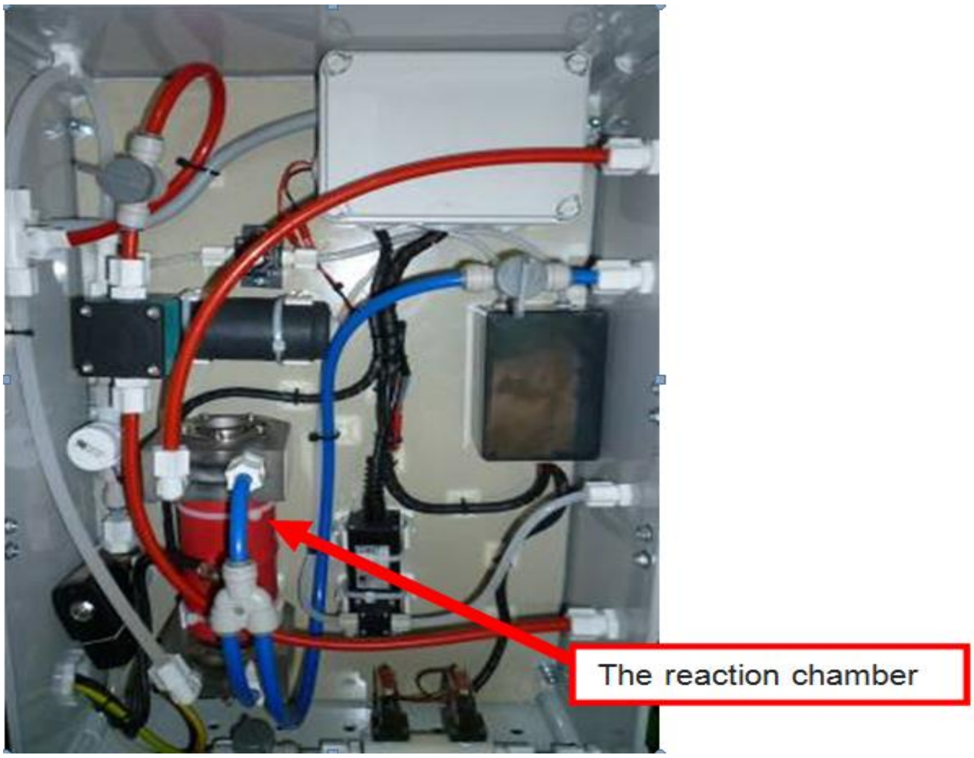


Figure 31: A general view supplied with shelter and IBC made to remedy

Source: PROTE LTD (2015)

5. Discussion

In Guinea, the access to drinkable water has not always been easy and still is not. Until now, one of the biggest challenges of the country has been about the amount of accessible water for the population. Compared to most of the African countries, Guinea has more than enough water sources, as all together constitutes 23 rivers basins with 14 international basins (see Table 1).

Following the evolution of the water sector in Guinea since the 80s with only 40% of access to drinkable water until today which is over 70%, we realize that with the outside help, the quantity of water produced has increased. The supply of drinkable water for the capital town Conakry has increased up to 164,000 m^3 /day, where 85% of it is treated by Yessoulou water treatment unit 1,2 and 3 (see Table 3). As the biggest water purification plants, the complex of Yessoulou by itself produced a large amount of treated water (123,000 m^3/day = 1,500 m^3/s). But even with that (see Table 2), according to the data from 2012, the shortage was of 122,000 m^3/ day. Nowadays, the shortage is even higher because of many reasons, such as increase of urban population, evolution of the life standard and other which increased the need for water in the capital town Conakry. The more the need of the population for purified water increases, the more we try to increase the quantity of the production and focus less on the quality; reason why the focus of the study was on the quality of treated and distributed water in the capital town Conakry.

By analysing the quality of the current treated water, the critical points were found (temperature and turbidity). Base on those results, with the help of a specialist, we proposed an alternative solution to the current water treatment plant of Yessoulou, with a design of an auxiliary water purification unit to improve the quality of the produced water. Compared to the existing technology, the auxiliary plant would help upgrade up to the standards the parameters of the produce water. As shown on schema 5, the biggest part of the screening with the electro-coagulant (innovative technology) will be done in the lake, where the water goes from the great fall before it reaches the treatment plant. Also in the auxiliary water treatment plant, the disinfection was moved to the end of the purification process after the final liming; after which it goes to the tank where the water will cooldown. The implementation of these new technologies would ensure a better quality of drinkable water compare to the ones currently produced. That would be done by the cooldown of the water in the tank before the distribution to the different reservoirs in the capital town Conakry; in that case the temperature could decrease to the requested standard. Also, the turbidity would decrease and the water would be safer for the consumers.

6. Conclusion

The result of the study, which lasted 16 months, was used to design a suitable auxiliary water purification unit for the main treatment centre for the capital town Conakry. The study was conducted in different stages, starting with samples and data collections. The primary data got from the analyses on the samples collected in Yessoulou and on the households, complete with the secondary data from the SEG were used to evaluate the quality of the water produced and deserved in Conakry.

The evaluation of the analysis results highlighted the critical points which could be externally influenced (high temperature and turbidity). Therefore, based on that information, we designed an auxiliary water purification unit which would improve the output of the main treatment centre (decrease of the temperature and turbidity).

The implementation of the new design of auxiliary water purification unit with modern technologies would be more recommended in Guinea, more precisely in Yessoulou. By this implementation, it is not only the quality of the produced water which is being improved, but also the guaranteed health of the consumers and that means an upgrade of life standard.

7. References

Alley E. 2007. Water quality control handbook. Alexandria: WEF Press. Various pages. Available at http://accessengineeringlibrary.com/browse/water-quality-control-handbook-second-edition: Accessed 2015-10-12.

AMCOW. 2002. The water page – The African water page. Available at http://www.africanwater.org/amcow.htm: Accessed 2015-12-18.

Bah, AK., Morin, R, Diallo, A. 2009. Differentiated Domestic Water rate and Consumption in African Cities: The case study of Conakry, Canadian Journal of Development Studies, Volume: 28, Issue: 3-4, Pages: 415 – 437. ISSN 0225-5189.

British Columbia. 1998. Tackling non-point source water pollution in British Columbia*:* An action plan. Victoria: British Columbia Ministry of Environment, Lands and Parks. 65p. Available at http://www.env.gov.bc.ca/wat/wq/bmps/npsaction.html: Accessed 2015-12-13.

Brook Cowen, Penelope J. 1996. The Guinea water lease: five years on, lessons in private sector participation. . Public policy for the private sector; Note no. 78. Washington, D.C.: World Bank.

Casiday R, Noelken G, Frey R. 2008. Washington University in St Louis. Available at http://www.chemistry.wustl.edu/~edudev/LabTutorials/Water/PublicWaterSupply/PublicWaterSupply.html : Accessed 2016-1-16.

CEFAN.2015. L'aménagement linguistique dans le monde. Available at http://www.axl.cefan.ulaval.ca/afrique/guinee_franco.htm: Accessed 2015- 9-22.

DIALLO. 2006. Etude sur le rôle des politiques du secteur de l'eau dans la Stratégie de Réduction de la Pauvreté (SRP) en Guinée. Conakry: 45p.

FAO.2005. AQUASTAT. Available at http://www.fao.org/nr/water/aquastat/countries_regions/gin/indexfra.stm: Accessed 2015-4-14.

FONDRIEST ENVIRONMENTAL INC. 2015. Fundamentals of Environmental Measurements. Available at http://www.fondriest.com/environmental-measurements/parameters/water-quality/turbidity-total-suspended-solids-water-clarity/: Accessed 2016-1-10.

Human Development Report 2006 – Water for Human Development, ISBN 0-230-50058-7.

Kaneko M. 2012. Project of Improvement of Drinking Water Supply in Conakry. Earth and Human Corporation: 33p.

McMichael, Anthony J. 2000. The urban environment and health in a world of increasing globalization issues for developing countries: Bulletin of the World Health Organization 78.9: 1117-1126.

Menard C, George R G C. 2002. Web Guinée. Available at http://www.webguinee.net/bibliotheque/economie/eau/menard_clarke/water_supply_thirsting_efficiency.html: Accessed 2016-1-18.

Menard, Claude; Clarke, George. 2000. A transitory regime: water supply in Conakry, Guinea. Policy, Research working paper; no.WPS 2362. Washington, DC: World Bank.

Nazir H. 2015. Assessment of Water Quality and Proposal of Appropriate Water Purification Unit for Agricultural Area of Province Lattakia, Syria. Ph.D. Thesis, Prague: Czech University of Life Sciences Prague, 131p.

NCS Pearson. 2016. Tutor Vista. Available at http://chemistry.tutorvista.com/physical-chemistry/flocculation.html : Accessed 2016-1-16.

PROTE LTD. 2015. Internal documents used in this project. Prague: PROTE LTD.

Triche T. 1990. Private Participation in the Delivery of Guinea's Water Supply Services. Washington, D.C.: World Bank Publications. 477p.

SIAM. 2012. SIARL. Available at http://www.siarl.fr/station_epuration_01.html: Accessed 2015-11-9.

UN-WATER. 2009. United Nations world water development report 3: Water in a changing world, UNESCO ISBN: 978-9-23104-095-5.

SEG. 2009. Water Pipelines report. Conakry: Société des Eaux de Guinée. 67p.

SEG. 2015. Information received during may data collection.

World Bank. 1998. Guinea - Second Water Supply Project. Washington, DC: World Bank. 43p.

World Bank. 2006. Guinea - Third Water Supply ad Sanitation Project. Washington, DC: World Bank. 32p.

Zeidan T. 2010. Escape 2 Guinea. Available at https://escape2guinea.wordpress.com/weekend-getaways/chutes-de-la-soumbadubreka/ : Accessed 2016-01-16.

8. Annexes

The disinfection module: **ASOR** (effective electrochemically activated solution)

INTRODUCTION

Currently, there is not a major development trend of chemical disinfectants development of new resources, but finding ways to intensify the already existing means.

For example, commonly, until recently used 6% strength hydrogen peroxide solution for sterilization and disinfection of a higher level, they are now looking for the technology of its application in the form of steam, or gas plasma, to reduce the corrosive effect, while maintaining or even increasing the biocidal activity. Activation of chemical disinfectants allows at minimum concentration of active ingredients to maintain or intensify bactericidal effect while reducing or completely excluding corrosion and destruction of the treated materials, and also a significant reduction in toxic effects on humans.

Time efficiency, concentration, temperature and conditions of use of active substances plays a major role in the process of disinfection products; medical treatment and recovery are the main parameters of any practical methodology. This trend is entirely consistent with the electrochemical activation saline ASOR (the acronym of "AktivovanýSolnýRoztok" meaning "Activated brine"). Manufacturing technology was developed originally for medical purposes for the first time in Russia and used in the veterinary sector, food industry, agriculture, water management, protection of public health, schools, sports facilities, spas and other areas in the EU, USA, Japan, and Southeast Asia.

CHARACTERISTICS AND COMPOSITION ASOR

The starting components of ASOR are usually drinking water and food salt which is added to water in a concentration of more than 5 g / l.

- Low overall mineralization (average 2.5 to 3.5 g / l) approaches electrochemically activated ASOR, according to the characteristics, the normal fresh drinking water or low mineral (spring) water and ensures its ecological purity. While drying on the treated surfaces to form a film, it has the effect of moisture absorption with porous materials, such as walls of the room. Into the air during the natural evaporation do not exclude the substances contained in the solution.

- Low concentrations of active substances in the electrochemically activated ASOR (in average 200 to 300 mg / l), it is safe for contact with the skin or mucosa. It also allows the security of the overall protection of products from materials susceptible to corrosion, such as carbon steel, using very simple methods and technical means.
- Broad spectrum chemical active substances (hydro peroxides, ozone, oxygen, oxygen compounds, chlorine), existing together only by the specific structure of electrochemically activated water solution, causing its high bactericidal, and virulicidní sporicidal activity, combined with excellent application properties.
- Relatively short time maintaining the highest sporicidal and virucidal activity, and its rapid loss during use (while performing) is electrochemically activated ASOR environmentally safe and after its application it is not necessary to carry out neutralization.

Chemical composition ASOR

Chemical composition of matter ASOR exactly corresponds to a chemical material composition of the starting solution, of which the main components are in all cases water and sodium chloride.

In the production ASOR reactions take place during which arise biocidal components ASOR - oxidants:

$$2Cl^- - 2e \rightarrow Cl_2;$$
$$2H_2O - 4e \rightarrow 4H^+ + O_2;$$
$$Cl_2 + H_2O \rightarrow HClO + HCI;$$
$$HCI + NaOH \rightarrow NaCI + H_2;$$
$$Cl^- + 2OH^- - 2e \rightarrow ClO^- + H_2O;$$
$$Cl^- + 4OH^- - 5e \rightarrow CIO_2 + 2H_2O;$$
$$O_2 + 2OH^- - 3e \rightarrow O_2 + H_2O;$$
$$HO_2^- - e \rightarrow HO^{\bullet}_2;$$
$$OH^- - e \rightarrow HO^{\bullet};$$
$$ClO^- + H_2O_2 \rightarrow {}^1O_2 + Cl^- + H_2O.$$

The more chloride containing starting solution, the greater the concentration of oxidant can be achieved in ASOR.

Given the results of experimental research activities ASOR are major factors:

- Electrochemically synthesized oxidants: These compounds during storage undergo a number of structurally-energy and chemical transformations. Their stability in ASOR is dependent on the total concentration of metastable products of electrochemical reaction, and on the relationship of the concentration of various metastable products of electrochemical reaction. The ones which are in solution in the catalytically relevant concentrations (e.g. H_2O_2) rapidly disappear due to its role as initiators of various chemical reactions. The main active components are relatively resistant and with correct storage have the ability to persist in ASOR long time.
- Electrically charged micro bubbles electrolysis gases stabilized uncompensated electrical charges impinging on the boundary phase "Gas-liquid". Microbubble size varies from 0.1 to 60 microns, their concentration can reach 106 ml / l. Definitions "micro bubbles" in a small size of such electrically active disturbance cannot be determined due to the fact that in the monitored objects no precise boundary phases "gas-fluid". For example, Japanese scientists define a similar disturbance small size as a monastery. For example, Japanese scientists define a similar disturbance small size as a monastery. In ASOR are micro bubbles evenly distributed in the whole volume and maintain when applying for 20-150 hours (depending on the size of the other physical-chemical properties of the solution). Micro bubbles are electrically and chemically active components and can play the role of catalysts, inhibitors and redox reaction. Given that the micro bubbles are ASOR represented gases generated during anodic and cathode processes active components ASOR represent joined to one another red-ox pair, thereby increasing the overall virulicidní, sporicidal and bactericidal ability ASOR.
- Unbalanced structure ASOR conditional statistical interaction of carbon-molecular particles after electrochemical transformation, which is characterized by the closest neighbourhood selected particles, is caused by the natural interaction between the particles and their degree of interaction.

Characteristics of ASOR

ASOR is a colourless, clear liquid. ASOR concentrates containing more than 4 g / l of sodium chloride have an odour similar to the smell of chlorinated water in swimming pools. In applications where there are claimed decreases with the content less than 2 g / l NaCl have no odour.

ASOR is in a class minimal toxicity that still reduced at reducing the concentration of sodium chloride in the starting solution, or in the reduction of oxidants see separate document "Hazard Assessment of ASOR").

ASOR at a sodium chloride concentration of from 0.5 to 0.3% and the content of oxidants from 0.05 to 0.04% does not at a single local action, skin irritation. Repeated exposure may cause skin dryness and allergic reactions.

ASOR containing oxidants 0.02% and total mineralization of 0.25 to 0.35% does not cause respiratory irritation or eye. ASOR oxidant containing 0.05% or more causes respiratory irritation and eye irritation. ASOR containing sodium chloride in the starting solution of less than 0.25%, are very weakly expressed by complex features determining toxicity parameters.

ASOR may be stored in a hermetically sealable glass or plastic container of any volume at room temperature in a sunny place protected from light. ASOR storage at low temperatures or frozen, extends its period of relaxation, thereby increasing the time and maintaining its highest biocidal activity.

When heated to 40 ° C biocidal activity ASOR rise by 30 to 100%, which is caused by the combined effect of chemical and temperature factors. Upon further heating to 80 ° C runs slow reduction in the biocidal activity ASOR, ie. ASOR that with a temperature of about 80 ° C has approximately the same biocidal effect as freshly made ASOR with the same concentration of oxidants at 20 ° C. Cooking biocide (sporicidal) ASOR ability to quickly disappear. In the presence of contamination of organic origin (blood, etc.), the disinfecting ability ASOR decreases.

Electrochemically activated ASOR has universal spectrum of biocidal efficacy, ie. has devastating effects on all large system of microorganisms (bacteria incl. Mycobacterium tuberculosis, viruses, including virus-agents polio and hepatitis A, B, C, HIV, fungi, spores and protozoa), does not in fact damage the tissue cells of humans and other higher organisms, ie. somatic animal cells of multicellular systems.

Microorganisms during their life activities produce substances and have no effective protection systems against oxidants, so electrochemically activated biocidal solutions are highly toxic to them. Biocide in an electrochemically activated ASOR, are not toxic for human somatic cells, they are represented oxidants similar to those produced by cells of higher organisms.

Among other factors, high biocidal activity ASOR includes the following:

- Low mineralization ASOR and the increased hydration ability, due to the increased permeability of cell walls and membranes, create conditions for intensive osmotic transfer of oxidants into the intracellular environment. Osmotic transfer oxidants across membranes and membranes of microbial cells are much more intense than transmission through membranes of somatic cells due to a significant difference in the gradient of the cell types.
- Accelerated electroosmotic transfer oxidants into bacterial cells help numerous electrically charged micro bubbles electrolysis gases which form the zones in contact with biopolymers, strong local electric field with a high degree of heterogeneity

The presence of electrolysis gases in ASOR, differing according to the chemical composition and physical properties of oxidants deprives the microorganisms of adaptation options (bacteria become resistant to the product) and guarantees a high biocidal effect even at low concentrations.

The Table below shows the characteristics of ASOR, compared with disinfectants commonly used in health care.

Table 1: Comparing the characteristics of ASOR and other disinfecting solutions.

Name, Manufacturer	The concentration of the working solution,%	Characteristics of the antimicrobial activity					Connection disinfecting and washing properties	Adaptation of microorganisms to a solution
		Bacteria	Mycobacteria	Beliefs	Mushroom	Scanty		
ASOR	0,01-0,05	+	+	+	+	+	Yes	No
Hypochlorite sodium (Russia, USA, etc.).	0,1-0,5	+	+	+	+	-	No	Yes
Percept (USA)	0,5	+	+	+	-	-	No	Yes
Chloramine (Russia)	1,0-3,0	+	+	+	+	-	No	Yes
Chlorhexidine biglukonat (Russia)	0,5-4,0	+	+	+	-	-	No	Yes
Lyzoformin-special (Switzerland)	0,5-4,0	+	-	+	-	-	No	Yes

Virkon KRKA (Slovenia)	0,5-2,0	+	-	+	-	-	No	Yes
Lizetol-AF (Germany)	2,0-5,0	+	+	+	+	-	No	Yes
Syrex (USA)	2,0	+	+	+	+	-	No	Yes

Bactericidal activity

Bactericidal activity against the following organisms is not a complete list of expected efficacy, which was monitored in applications ASOR in the EU, USA, Russia, Japan, Southeast Asia:

Listeria monocytogenes Legionella

Pseudomonas aeruginosa Staphylococcus aureus Salmonella choleraesuis
Enterobacter cloacae Streptococcus pyogenes Streptococcus facaelis
Enterobacter aerogenes Salmonella typhimurium Klebsiella pneumoniae
Proteus vulgaris SerratiamarcescensShigellaflexneri
Shigellasonnei Salmonella typhi Proteus mirabilis

Fusobacterium necrophorum
E. coli
Staphylococcus aureus (antibiotic resistant)
Staphylococcus facaelis (antibiotic resistant)
E.coli (antibiotic resistant)
Klebsiella pneumoniae (antibiotic resistant)
Staphylococcus epidermidis (antibiotic resistant)
Pseudomonas aeruginosa (antibiotic resistant)
Canine parvovirus Porcine parvovirus Rubella
Canine distemper virus Influenza virusHonkong A Adenovirus typ 4
Rabies virus Herpes simplex typ 1 Pseudorabies virus
Feline leukemia virus Herpes simplex typ 2 Infectious bronchitis virus (Avian IBV)
Feline picornavirus Vaccinia

Kills HIV - 1 (AIDS) on surfaces / objects soiled with blood or body fluids / facilities where it can be assumed pollution inanimate surfaces / blood or body fluids / and where we can assume risk of transmission of human immunodeficiency virus type 1 (HIV - 1) (jointed with AIDS).

Avian influenza - as a precaution against infection with bird flu were treating poultry farms in Vietnam, Malaysia aerosol application ASOR and thus kept farms were infected by this virus.

Intentional bacterial contamination (terrorist threats) and the spread of the epidemic

Broad spectrum utilization efficiency ASOR with the support of its mechanism of action and with regard to the harmlessness to the human body when its application is recommended use ASOR for immediate deployment on suspicion of deliberate spread of bacterial contamination (anthrax), or an epidemic! It can be used directly in the areas of movement of people, gathering a large number of people, animals. Treatment spaces for their presence!

SCOPE OF USE

In parallel with the creation of new technical systems are developing and improving methodology using electrochemically activated ASOR, not only in health but also in other areas, such as the disinfection of drinking water, swimming pool water, municipal and industrial wastewater and disinfection in the food industry, veterinary, animal production, prevention of epidemics and bacterial contamination.

Scope of use for emergency systems and protection of population

Personal protection: Persons who may be on the surface of the body of bacterially contaminated perform washing limbs, body, face solution ASOR 1: 5 Equally perform preventive cleansing of the person handling the suspicious material moving in a contaminated environment, performing decontamination of others. Method of execution - using the bath, spray manual applicators, passes by aerosol application. After performing disinfection, it is not required rinsing with pure water.

Cleansing things, instruments and equipment: Things used during the intervention in suspected contaminated area or particular situation decontamination and laying in a bath with a solution ASOR 1: 10-20 for 10 minutes; or will be carried out by aerosol spraying device 1: the fifth We recommend gross contamination and wash in the washing bath Business treat ASOR in the ratio of 1: 100. After performing disinfection, it is not required rinsing with pure water.

Decontamination spaces and premises: In carrying out the intervention spaces (such as the floods), it is recommended to use small arms; machine sprinkles or siphoned into pressure washing. A very effective method is the application by the aerosol generator with a dose of 50 ml of concentrate per $1m^3$ of air. For preventive applications, it is suitable to use the concentration of the solution at a ratio of 1: 5 for the same dosage of the aerosol generator. Rough biofouling is necessary to remove the pollution and treat the surface again. The ratio of the concentration 1:20 during preventive examination 1: 100; contaminant developed to increase the concentration of 1: 5 to 1: 1.

In carrying out the intervention in the premises of buildings, halls (pigs, poultry, etc.), Transport equipment applications performed using aerosol generator with a dose of 30-50 ml concentrate per one cubic meter of air. For preventive treatment of air ventilation systems in buildings, tunnels and under sufficient dosage of 5 ml per 1 cubic meter of air treated.

Aerial disinfection carried out in the halls, establishments for food preparation, food, applications for indoor air-conditioning, interior conference rooms, vehicles (buses, planes, trains, metro, etc.), and so prevents the spread of diseases of viral origin, airborne bacterial contamination, enhance the feeling of fresh air and supports the immune system (for health as the inhalation method).

Toilets: WC is done normal daily cleaning, including washing basins, urinals, toilet bowls, floors and their subsequent spraying ASOR. General cleaning, including all elements of conventional cleaning with additional water wash resistant wall surfaces 0.05% sodium ASOR is done once a week.

Systems for epidemics and natural disasters: Application ASOR to ensure the prevention of spread of epidemic risk is carried out by dosing solution at a ratio of 1: 5 on the running and walking mat. At 1:20 into the sedge frames or aerosol of fastening device decontamination lines of vehicles and persons placed on communication directions of the affected grounds and buildings.

Securing emergency water contamination after the flood: For the purpose of resolving the necessary resources to ensure water (potable, utility) will be treatment- disinfect containers, tanks, reservoirs, wells rinsing the walls 1:20. For wells injected into wells

ASOR volume of 1: 100 and then exhaust volume wells, reservoirs, ponds, reservoirs. Then, it is applied to the wells ASOR volume ratio of 1:500.

Water treatment:

Tests have shown that ASOR is an effective disinfectant used in the proportions 1: 500-2000 for drinking water and industrial water. Determination of organic chlorine compounds and tri halogens methane proved significantly less than is permissible under German standards for drinking water, not to mention the concentration of free chlorine in solution ASOR.

Furthermore, since the formation of halogens were significantly lower than is permissible under German standards for drinking water and the pH value only slightly decreased, the solution is recommended as a safe and effective disinfectant.

ASOR parameters of a solution are as follows:

- PH of from 6.0 to 8.5
- Concentrations (general) active chlorine is from 500 to 700 mg / l - very low concentration of active chlorine, the product ASOR dispersed in water as shown in the table below, shows no toxic effect or form toxic compounds
- Very high efficiency with low oxidant (hundredths of percentages) concentrations of active substances which are not harmful chemically or do not affect other vital characteristics of the purified water and do not form any toxic compounds.

Treated water	Active chlorine concentration (in the treated water)	
	Hypochlorite	ASOR
Drinking water	1-4 mg/l	0.25-0.5 mg/l
Surface water	35-55 mg/l	5-10 g/l

- Disinfection result (in the absence of excessive amounts of organic deposits) is that TMC is equal to 0.
- Chemical and other vital characteristics of the water are not affected.
- ASOR penetrates pores finishes water pipes, but also other materials.

- ASOR eliminates biofilm and algae in the grids.
- The pipeline and facilities may not be flushed with water after disinfection.
- ASOR harm the original natural properties of water ASOR reduces the taste and smell of
- Chlorine enhances the natural flavour and aroma.
- ASOR may be stored and kept for a period of 9 months.
- Easy dosage.
- High level of safety: no hazardous chemicals produced or used.

Mobile tanks:

To maintain the purity of the bacterial walls and devices of tanks, it is necessary in the ratio 1: 1000 to dispense ASOR volume tanks.

Water in a closed cycle (cooling bath, air conditioning, artificial fountains, lagoons, pools, waterfalls, air fresheners, humidifiers) Application of ASOR prevents bacterial contamination and of fine droplets into the air with fumes will disinfect the air!

SERVICE DELIVERY ASOR

Storage

ASOR must be stored in containers supplier to the store for a place in temperatures exceeding 35 ° C, without direct sunshine. When the contents freeze ASOR quality will not change. Quality Guarantee concentrate - preserving production parameters is 9 months. The manufacturer supplies ASOR in 5, 30 and 1000 l containers.

Environmental safety and rehabilitation

Ecological safety ASOR solution consist of metastable (the time of self-reactive) chlorine compounds and oxygen, after which the degradation of natural substances produced chemically inactive. Relatively short time maintaining the highest biocide, and virucidal sporicidal activity and its rapid loss during use (while performing discharges ORP) is electrochemically activated ASOR environmentally safe (this is the saline solution) and after the application is not necessary to carry out neutralization.

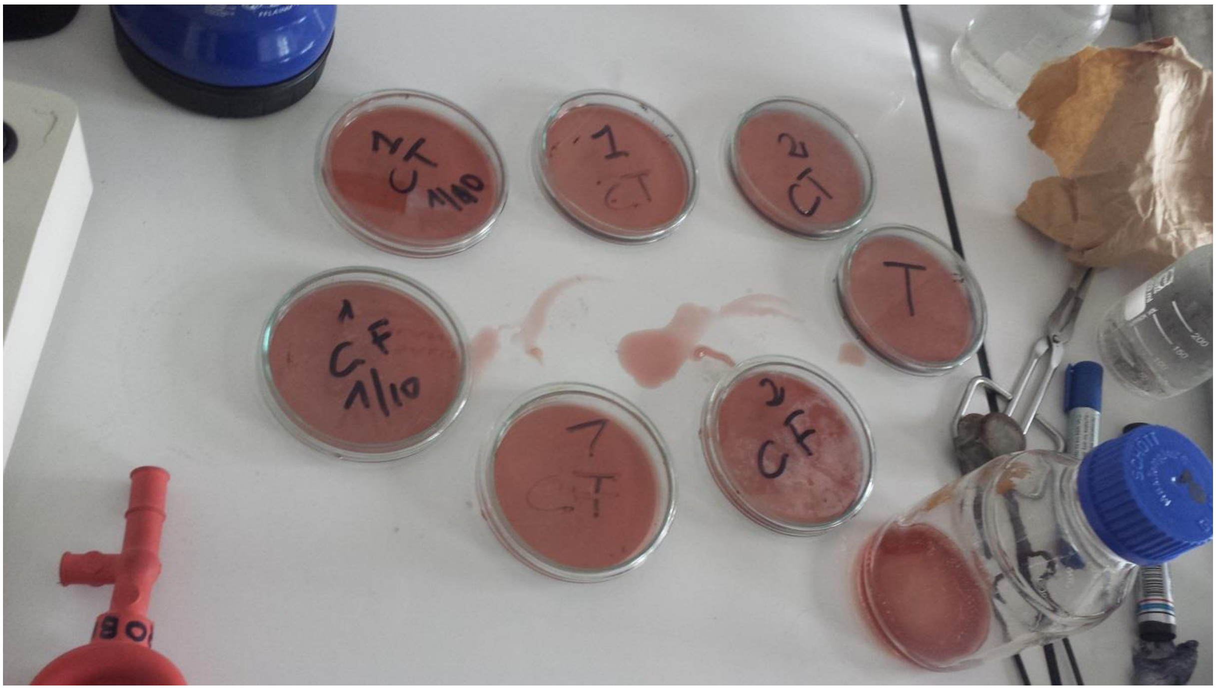
ASOR removal - after a period of life can make measurements of parameters concentrate and finish his use in normal operation by changing the dosage regime or directly after the wash up on the surfaces of floors, walls, equipment and the like. At the request of the client contractor removes expired ASOR.

In case the use of ASOR Rescue Systems- services to the population, etc. Contractor removed after 6 months untapped ASOR and deliver newly manufactured

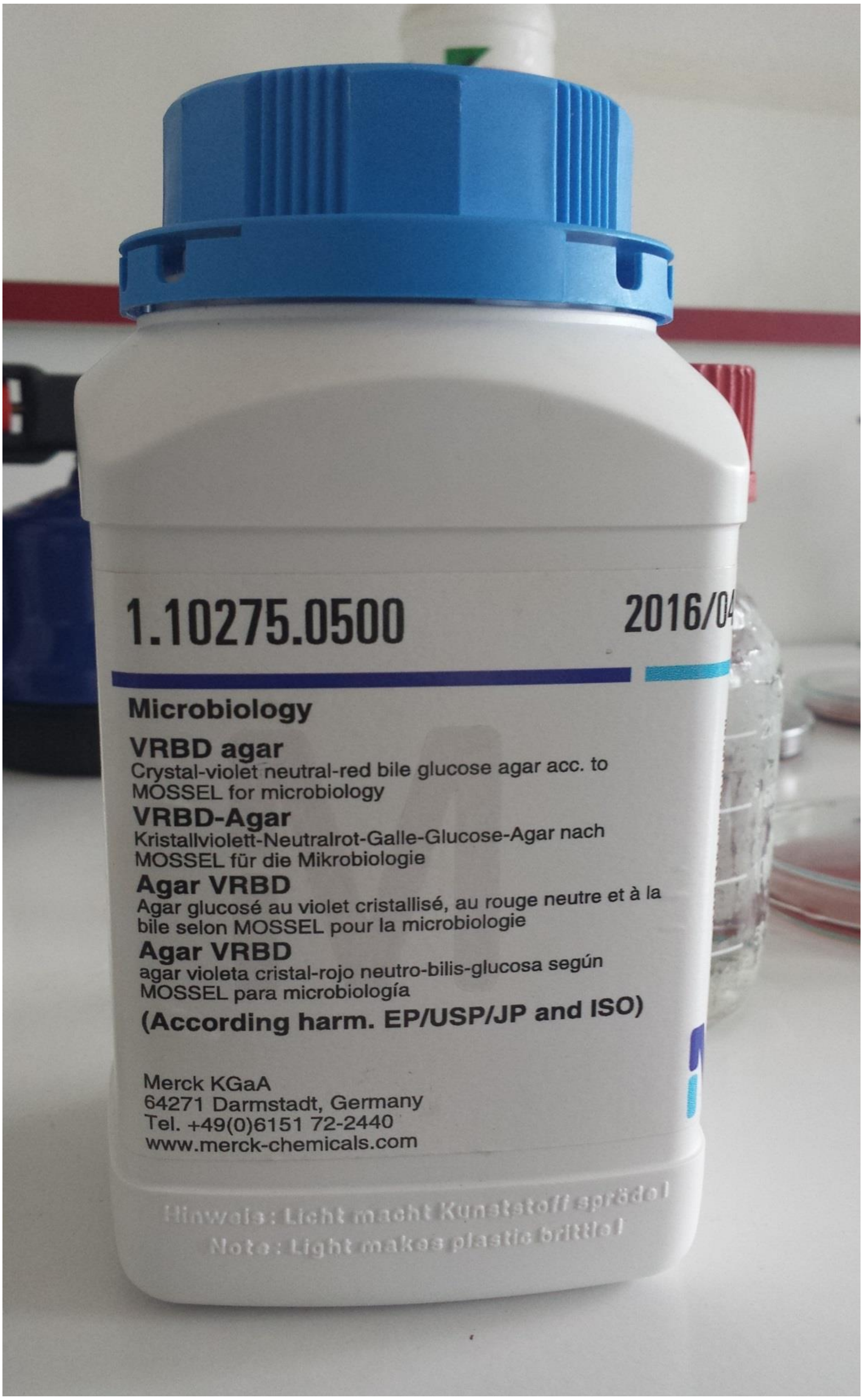
Pictures of samples collection in the household

Laboratory pictures

Calculations of total and fecal coliforms


CT
1/10
1
CT
2
CT
T
1
CF
1/10
CT
2
CF

Chemical used during the process of coliforms calculation



SEG team with me in Yessoulou

SEG Team and Mr Nabe with during the visite of Kakoulima Spring (see table 2)

Ca $(OH)_2$ used in Yessoulou for the pre-liming