SUSTAINABLE WATER MANAGEMENT IN SCANTOGO BY PHYTOEPURATION TECHNIQUE

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EDITION 2018

ABSTRACT

Good wastewater management in quarries is a major challenge for sustainable development. This project to set up a phyto-purification station has been proposed to sustainably manage wastewater at SCANTOGO. The phyto-station in place is composed of three basins (vertically flowing filter tank, horizontally-flush filter basin and lagoon). The results we have obtained clearly show the effectiveness of such a system for the treatment of wastewater. Pollution abatement achieved: 96.66% removal of COD; 95.83% of BOD5; 91.66% of the total nitrogen, 84.62% of the total phosphorus; 90.87% of the total Coliforms and 96.31% of the thermo tolerant Coliforms. The results obtained show that the quality of the water after treatment is much higher than that taken at the entrance of the basins.

INTRODUCTION

Good wastewater management in quarries is a major challenge for sustainable development. The career of SCAN TOGO, to face this challenge, has set up an artificial purification station for wastewater. Artificial stations are generally complex and require a high level of skill and high-tech equipment. There is a purely natural mode of purification where the active agents in the process are plants. For this technique, human intervention is very limited and the installation is not too expensive (Saggai, 2004). These are aquatic plant water treatment systems that function as biological assimilators by removing both biodegradable and non-biodegradable compounds as well as nutrients, metals and pathogenic microorganisms (Suwasa, 2011). It is in this logic that we proposed this project of sustainable management of wastewater by the phytopurification technique.

1.1 OBJECTIVES OF THE PROJECT

This project aims to propose a wastewater treatment system for plants to sustainably manage wastewater at SCANTOGO. Specifically, it aims to:

- Establish a powerful phytopurification plant;
- Evaluate the impact of the reuse of treated water in irrigation.

2 MATERIAL AND METHODS

2.1 PRESENTATION OF THE STUDY AREA

The site is located in the Maritime Region of Togo, Yoto Prefecture, about 45 km from the coast and 8 km northeast of the town of Tabligbo, in the village of Sika-Kondji. The area of direct influence covers part of the Tokpli township more precisely the geographical perimeters of the localities of Sika Kondji, Assou kondji, Nyéda Kondji, Akladjénou and Logokpo. This area consists of a large swampy area to the north of Ziome-Kondji and Sika-Kondji, including the eastern end of the quarry that touches the border of the Republic of Benin, materialized by the Mono River. As for the zone of indirect influence, it covers the entire Tokpli canton (Kokou, 2016), (Figure 1).

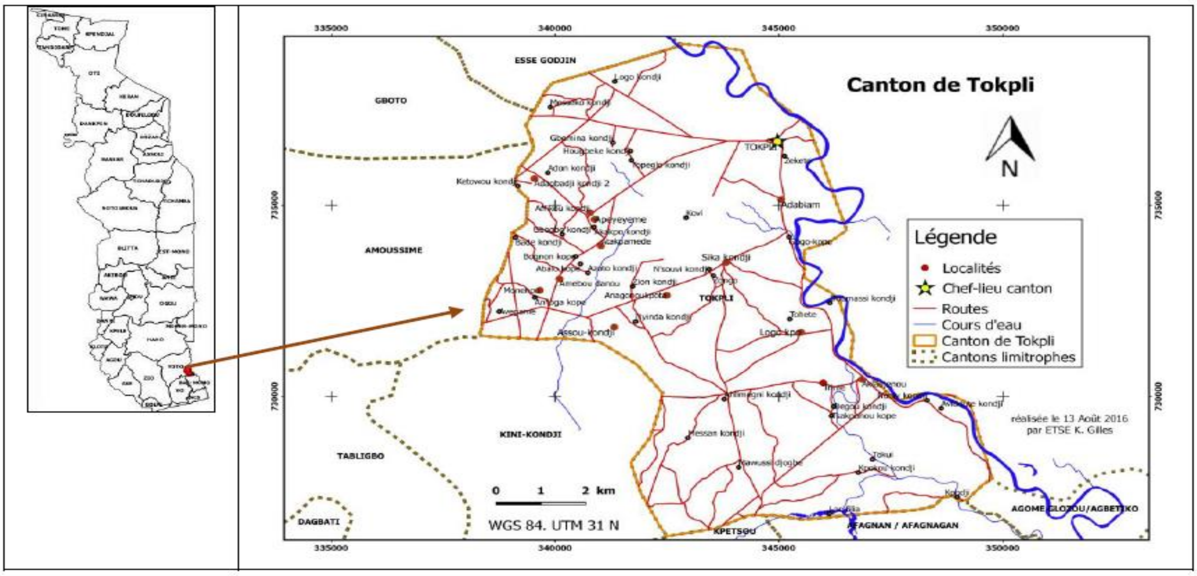

Figure 1: Location of the study area

2.2 VEGETABLE EQUIPMENT

Beyond the aesthetic aspect, the purifying plants have been chosen according to their purifying property. These are mainly native species: *Typha latifolia, Phragmites mauritianus, Canna indica, Pistia stratiotes and Nymphaea alba.*

NB: Subsequently we realized that *Canna indica and Pistia stratiotes* are invasive species, so we destroyed these species in order to preserve the environment.

Photo 1: Typha latifolia

Photo 2: Phragmites mauritianus

Photo 3: Canna indica

Photo 4: Pistia stratiotes

Photo 5: Nymphaea alba

2.3 COMPONENTS OF THE FILTER (SUBSTRATE)

The substrates used consist of sand, gravel, gravel and organic materials (compost). These substrates are washed, freed from all the impurities and are arranged in different ways according to the type of purification basin.

Photo 6: The components of the filter (substrate)

2.4 WASTEWATER

The waste water used comes from the septic tank and is composed of both sewage and greywater, it is called "pit all waters". Pretreatment of wastewater is carried out at this level. Solids are made liquid (hydrolyze). This liquefaction is caused by fermentation by means of anaerobic bacteria, that is, living without oxygen.

Photo 7: 3.3 Wastewater

3 EXPERIMENTAL APPARATUS

The Phyto-station is composed of:

- planted filter basin with vertical flow;
- planted filter basin with horizontal flow;
- Lagooning pond.

3.1 SIZING OF THE BASINS

For the experimental phase, the dimensioning chosen corresponds to that of 1 EH (equivalent-inhabitant).

Table I: Basin dimensioning

	Vertical filter basin	**Horizontal filter basin**	**Lagooning pond**
Area	1,3 m^2	1,3 m^2	1,8 m2
Depth	0.8 m	0.7 m	0.3 m
Slope	Minimum slope of land is 5% (gravity flow)		
Drainage	- Distribution pipe by tarpaulin - Perforated collection pipe placed at the bottom of the bed	- Collection Gabion - Tube drain arranged in the evacuation gabions	Gravity drainage according to the slope of the basin
Ventilation	A ventilation chimney is placed vertically by connecting the collection pipe.	No ventilation	Ventilation in the free space under the action of the wind

Photo 8: Vertical basin piping

Photo 9: perforated pipe

Photo 10: Horizontal basin piping system

3.2 LAYOUT OF SUBSTRATE AND PLANTS IN BASINS

➢ **The vertical filter basin**

The vertical filter basin is filled with substrate of different superimposed granulometries. The substrates are arranged from the bottom to the top of:

- draining layer (gravel);
- transition layer (gravel) and
- filter layer (coarse sand).

Macrophyte species (Typha latifolia, Phragmites mauritianus and Canna indica) are planted in the substrate at a rate of 4 to 6 plants / m2 in the pond.

➢ **The horizontal filter basin**

The horizontal filter basin is filled with vertically arranged substrates. From the entrance to the outlet of the effluent:

- feeding gabion (gravel);
- filter layer (coarse sand & chippings) and
- Evacuation gabion (gravel).

In the basin, macrophyte species (Typha latifolia, Phragmites mauritianus and Canna indica) are planted only at the level of the filter layer, at the rate of 4 to 6 feet of plants per m2.

➢ **Lagoon basin**

The lagoon system consists of two watertight basins arranged in series and communicating. The basins are filled with open water under the action of the wind. The bottom of the basins is filled with substrate (sand + gravel) on which aquatic plants (Pistia stratiotes) develop.

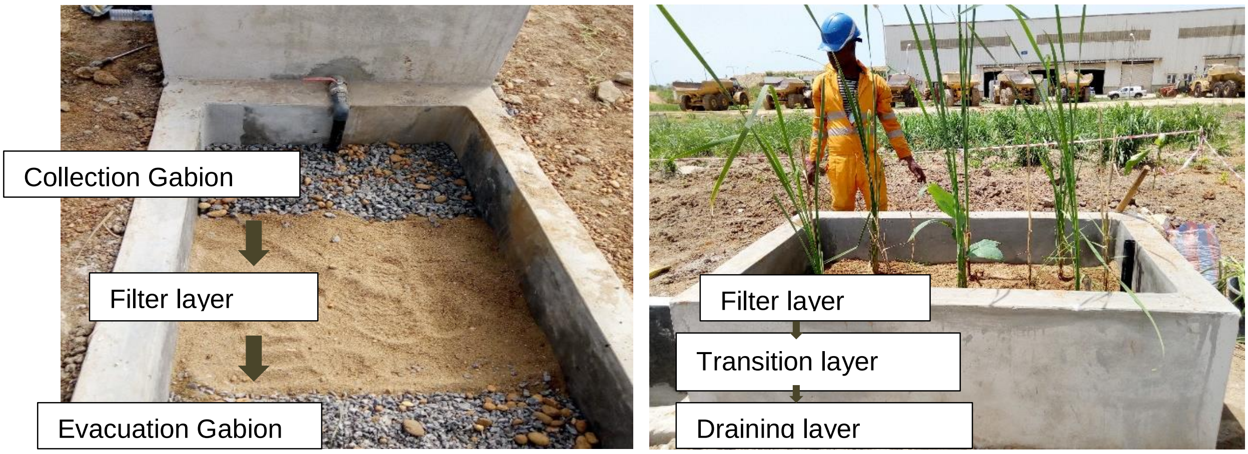

Photo 11: Arrangement of substrates and direction of flow

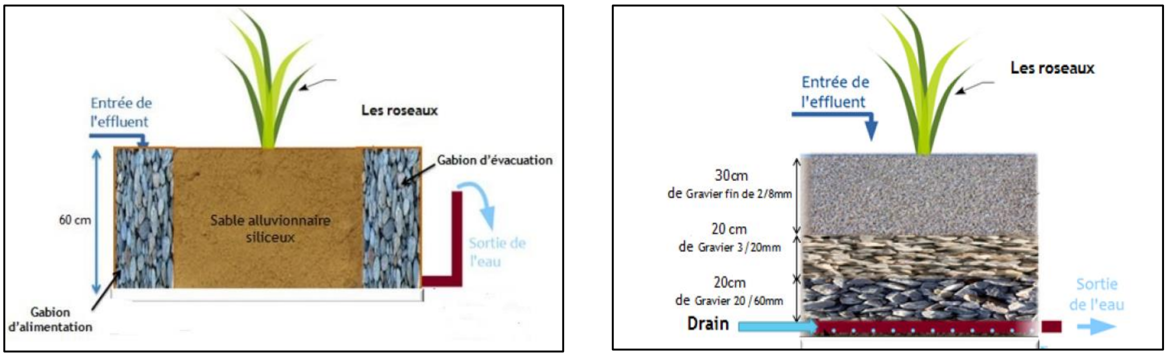

Figure 2: Layout of the substrate in the basins

Photo 12: Overview of basins after disposition

3.3 METHOD OF TREATMENT AFTER PLANT GROWTH IN THE BASIN

The effluents resulting from the pretreatment are thus discharged at the surface of the filter and percolate gravitarily through the substrate. It flows through it undergoing physical (filtration), chemical (adsorption, complexassion, etc.) and biological (biomass-supported) treatment.Most of the suspended solids (MES) are retained on the surface of the filter. by mechanical filtration of the substrate Organic matter is degraded and mineralized by microorganisms A part of soluble substances and nutrients are assimilated by plants to constitute biomass The presence of plants enhances the mechanical filtration of the substrate via a root system dense, and stimulates biodegradation activities.The partially treated effluent in the first basin, is collected to the second basin by the piping system laid at the bottom of the basin.In the second basin, the effluent circulates by gravity of the upstream downstream The effluent is distributed over the entire width and height of the filter by a distribution system at one end of the pond, it then flows horizontally through the substrate. The water level, set downstream of the filter by the height of the outlet pipe that is about 10 cm below the surface of the substrate. As a result, the bottom layer of the substrate is permanently saturated with water. Thus, anaerobic (deep parts of the filter) and aerobic (non-flooded surface layers, rhizosphere) zones are simultaneously in action. While passing through the filter, the solids still present in the water are retained by the root system of the plants, which allows the microorganisms of the substrate to degrade them effectively. Plants absorb soluble substances and accumulate them in their biomass. Microbial degradation and plant assimilation are thus more complete in this step than in the vertical filter. In addition, the anaerobic conditions that are predominantly present are favorable to denitrification.

The lagoon system set up for the phyto-station is composed of two watertight basins arranged in series and which communicate. The basins are filled with sewage and are free in the wind. The bottom of the basins is lined with substrate on which aquatic plants (Pistia stratiotes) develop. Aerobic bacteria grow in "free cultures". Near-surface filtration is aerobic, while deeper water and substrate generally work anaerobically. The first basin allows the reduction of the polluting carbon load and the second allows the reduction of nitrogen and phosphorus and refines the treatment.

3.4 SAMPLING AND LABORATORY ANALYSIS

The representative homogeneous sample is obtained without its characteristics being altered. The selected sampling points are: the entrance and the exit of the station. The samples are sent to the laboratories of the School of Biological and Food Techniques (ESTBA) at the University of Lomé for analysis. The pollution parameters to be measured are: pH, Electrical Conductivity, Salinity, Turbidity, MES (suspended solids), COD (Chemical Oxygen Demand), BOD (Biochemical Oxygen Demand), Total Nitrogen (NTK), Dissolved Oxygen (O2)), Total Phosphorus, Total Coliforms, Thermo Tolerant Coliforms.

4 RESULTS

4.1 AT THE BASIN LEVEL

For the vertical and horizontal filter basins, after three months, we noticed a rapid growth of the purifying plants (*Typha latifolia, Phragmites mauritianus*). This growth is explained by the fact that plants absorb soluble substances from wastewater and accumulate them in their biomass for their growth.

Photo 13: Plant growth after 1 month

Photo 14: Plant growth after 4 months

For the lagoon basin, after a period of three months, we noted a low growth of plants. We have taken the experiment by adding *Nymphaea alba*. Two months later, we found good growth of the plants.

Photo 15: Result of the first experience

Photo 16: Result of the second experiment

The phyto-purificatory pools have housed animal species that have also been involved in water purification.

Photo 17: Animal species identified in phyto-purificatory basins.

4.2 RESULTS OF ANALYSIS

The results of analysis of samples taken at the entry and exit of phyto-sation are presented in the following tables:

Table II: Physico-chemical and microbiological analysis results

Value	**Entrance Raw water**	**Exit Treated water**
PH	7.36	8.03
Conductivity	484 µs/cm	333 µs/cm
Salinity	346 mg /l	238 mg /l
Turbidity (NTU)	5.0	1.6
Suspended matter (MES)	< 10.0 mg /l	< 10.0 mg /l
COD	1200 mg/l	40.0 mg /l
BOD5	120 mg/l	5.0 mg /l
Total nitrogen (NTK)	16,8 mg/l	1.4 mg /l
Total Phosphorus	1.3 mg/l	< 0.2 mg /l
Dissolved oxygen (O2)	1.1 mg/l	7.5 mg /l
Hydrocarbon (Fats and oils)	< 5,0 mg /l	< 5,0 mg /l
Total coliforms	28500 Nbr/100 ml	105 Nbr/100 ml
Thermo tolerant coliforms	2600 Nbr/100 ml	96 Nbr/100 ml

4.3 DISCUSION

PH is an indicator of pollution. The pH value of the treated water obtained (8.03) is within the allowed range [5.5-8.5], as the limit values for discharges of liquid effluents discharged into the natural environment (J.O.R.A, 2003). Outside this range, pH has adverse effects on aquatic life and blocks self-purification processes (Sadek et al., 2012).

Electrical conductivity is used to evaluate overall mineralization and to estimate all of the soluble salts in water (Rodier, 1984). Its recorded value increases from 484 µs / cm at the entrance of the station to 333 µs / cm at the output. The latter is below the threshold limit of the Algerian standard which is equal to 2000 µS / cm (J. O.R.A, 1993). The salinity follows the same trends as the electrical conductivity, it goes from 346 mg / l at the entrance of the station to 238 mg / l at the exit. The value recorded at the exit of the station (238 mg / l) is lower than the Algerian norm (J.O.R.A, 1993).

The evolution of Total Nitrogen (NTK) increased from 16.8 mg / l at the inlet of the station to 1.4 mg / l at the outlet, with a purification efficiency of 91.66%. Total phosphorus increased from 1.3 mg / l at the inlet of the station to 0.2 mg / l at the outlet, with a purification efficiency of 84.62%. This decrease in Total Nitrogen and Total Phosphorus is due to the fact that the growth of phytoplankton and microorganisms involved in the purification of water require nutrients such as nitrogen and phosphorus. It is also caused by substrate adsorption and uptake by plants for their physiological needs. These values are below the wastewater discharge threshold of the WHO standard (RAHMANI, 2015) and the Algerian standard (120 mg / l) (J. O.R.A, 2006).

The value of the COD goes from 1200 mg / l at the entrance of the station to 40 mg / l at the exit for a reduction of 96.66%; This decrease is caused by the presence of plants that provide better physicochemical oxygen conditions that grow in the filter media through the leaves to the roots and stems by bacterial organisms that cause oxidation of COD. The value recorded at the inlet of the station does not exceed the wastewater discharge threshold of the WHO standard (90 mg / 1) (RAHMANI, 2015).

The value of BOD5 increases from 120.0 mg / l at the station inlet to 5 mg / l at the outlet for a 95.83% abatement. BOD5 is related to the load of biodegradable organic matter, as well as the richness of microorganisms. The difference in the removal of BOD5 is related to the supply of oxygen around the reed roots, in different ways. The value recorded at the inlet of the station does not exceed the wastewater discharge threshold of the WHO standard (40 mg / 1) (RAHMANI, 2015).

Regarding bacteriological parameters, total coliforms and fecal coliforms are used as indicators of the microbial quality of water, they can be indirectly associated with faecal pollution (Bedouh, 2014). There was a large decrease in total coliforms and faecal coliforms from the station entrance to the outlet (total coliforms of 28,500 Nbr / 100 ml at 105 Nbr / 100 ml and Thermo Tolerant Coliforms of 2600 Nbr / 100 ml at 96 Nbr / 100 ml) with a purification efficiency of 90.87% for the total coliforms and 96.31% for the thermo-tolerant coliforms.

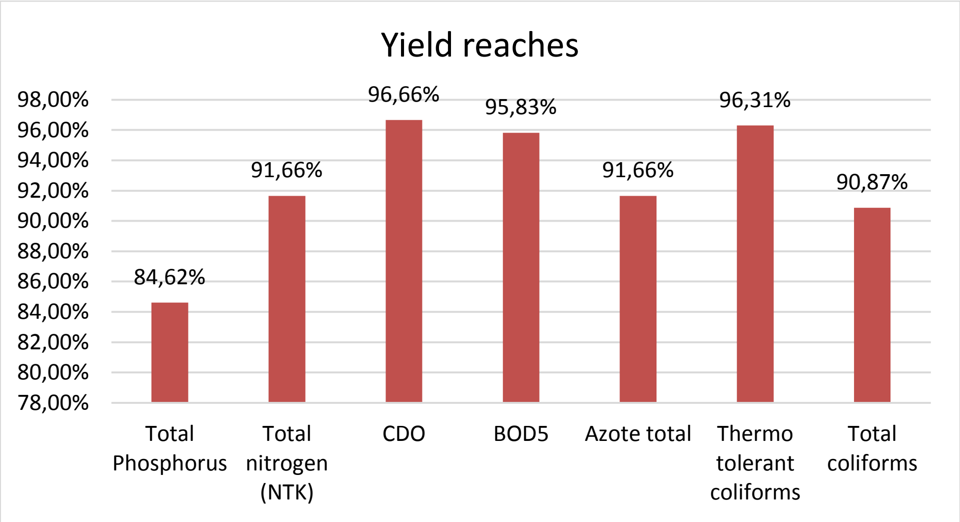

Figure 3: Purification performance of the phyto-station

These various results confirm the effectiveness of wastewater treatment by plants.

The treatment of sewage by phytopurification is economical, maintenance is reduced compared to "conventional treatment plants", and the installation is energy saving. We recommend that this experiment be expanded for wastewater treatment at SCANTOGO.

4.4 EXPERIMENTAL GREEN AREA

During this phase, we have, next to the basins, established a small green space, maintained with water from the treatment plant. The species of flower chosen for the green space are: mugwort, white periwinkle, hibiscus, green ficus. This green space reinforces the aesthetic aspect of the phyto purification plant and also enhances the quality of the surrounding air around the station.

Photo 18: Aesthetic appearance of the phyto-station

5 CONCLUSION

The station plays a key role in protecting the environment by eliminating odors, water stagnation in urban areas, safeguarding components and natural resources and especially it offers the opportunity to reuse wastewater in agricultural areas . In our work we used plants to treat wastewater. Our study is followed by an analysis of raw water quality and treated in the experimental test. The results of the main parameters revealed values that meet the requirements of the WHO and Algerian standards for phytopurification. The bacteriological analyzes confirm a system efficiency in the abatement of total coliforms and fecal coliforms. The results we have obtained clearly show the effectiveness of such a system for the treatment of wastewater. Pollution abatement achieved: 96.66% removal of COD; 95.83% of BOD5; 91.66% of the total nitrogen, 84.62% of the total phosphorus; 90.87% of the total Coliforms and 96.31% of the thermo tolerant Coliforms. The results obtained show that the quality of the water after treatment is much higher than that taken at the entrance of the basins. The treated water can partially meet the needs of crops and allow the economy of mineral fertilizers accordingly. The treatment of sewage by phytopurification is economical, maintenance is reduced compared to "conventional treatment plants", and the installation is energy saving. We recommend that this experiment be expanded for wastewater treatment at SCANTOGO.

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