International Journal of Progressive Sciences and Technologies (IJPSAT)
ISSN: 2509-0119.

Vol. 36 No. 2 January 2023, pp. 529-538

Assessment Of The Wastewater Treated Quality By The Technopole Wastewater Treatment Plant Of Dakar And Used For Irrigation

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Abstract – Sanitation is central to any policy for the effective and sustainable management of our environment. This study aims to assess the quality of treated wastewater by the Wastewater Treatment Plant (WWTP) of the Dakar Technopole and used for irrigation in this area. Indeed, the WWTP is composed of a primary settling tank, activated sludge tanks and a secondary settling tank. However, the tertiary treatment consists of a non-functioning sand filter and a disinfection tank. Thus, the concentration of total suspended matter (TSS) in wastewater is reduced from 2543 mg/L to 328 mg/L, that of biological oxygen demand (BOD_5) and chemical oxygen demand (COD) decreases from 800 mg/L to 238 mg/L and 3265 mg/L to 703 mg/L respectively. Regarding the concentration of nutrients, we have a decrease from 456.35 mg/L to 271 mg/L and from 19.75 mg/L to 5.8 mg/L for total nitrogen and total phosphorus respectively. In addition, the content of total coliforms goes from 4,600,000 CFU/100mL to 1,810,000 CFU/100mL. In conclusion, with the exception of total phosphorus and biochemical demand, the physicochemical and microbiological parameters concentration values of the treated wastewater largely exceed the guide values of the standards for reuse in agriculture recommended by the World Health Organization (WHO) and the Food Agriculture Organization of the United Nations (FAO). Therefore, appropriate technology such as phyto-purification could be applied to improve the quality of the treated wastewater and reused in agriculture.

Keywords – sanitation, wastewater, irrigation, guide value, Technopole

I. Introduction

More than 65% of households in African cities, especially those in sub-Saharan Africa, are not connected to a sewer system (AFWA, 2017). In most cases, the pumped faecal sludge is evacuated outside the cities without any prior treatment. This type of management poses a health and environmental problem. In developing countries, the lack of sanitation infrastructure has contributed to the underestimation of wastewater discharges into natural environments, exposing them to the risk of pollution and contamination of water resources, which aggravates the water crisis resulting in a potential reduction of exploitable water resources. All human activities, whether domestic, industrial, agricultural or artisanal, produce wastewater (Touria, 2014). Thus, the scarcity of water for different uses (civil, industrial, agricultural, recreational, etc.) creates the need to use unconventional water resources for irrigation (Plaza et al., 2013). Wastewater purification is therefore a necessity if we are to increase our water resources by recycling wastewater for industrial or agricultural purposes, in order to protect our marine and living environment (Abdelhamid, 2013).

Senegal currently has 13 treatment plants with a total treatment capacity of 36,066 m^3/day. The Senegalese capital released more than 200,000 m^3 of wastewater per day in 2006 (Akpo, 2006). The work of El Haite (2010) estimates that the production of wastewater in the Senegalese capital is around 67 million cubic meters (m^3) per year, and only a small amount is treated in wastewater treatment plants. The Senegalese capital Dakar, due to the rural exodus and the growth of its population, discharges large quantities of wastewater whose treatment poses problems (Akpo, 2006). The majority of wastewater discharged is not treated and discharged into the sea, into the streets or even into areas, which should be specially protected such as wetlands. In the departments of Pikine and Guédiawaye (Dakar region), which have 1,592,994 inhabitants, almost the entire population 96 % uses individual sanitation (RGPHAE, 2015). This results in a considerable sludge production of 1130 m^3/day (ONAS, 2014). The Senegal National Sanitation Office (ONAS) is a public industrial and commercial establishment. Its mission includes the operation and maintenance of wastewater and rainwater treatment facilities; the development of autonomous sanitation. There are several strategies for wastewater treatment, taking into account only those, which, due to their cost-effectiveness and easy applicability, can be used in developing countries. The choice of a specific treatment is strictly linked to the end use of the purified effluents, which can be reused in agriculture, discharged to the ground or to surface water bodies. In general, treated water should achieve the following basic objectives (Morel and Diener, 2006): (1) protect public health; (2) protect the environment; (3) ensure soil fertility (especially for agricultural reuse); (4) ensure cultural, social and economic acceptability; (5) adopt simple and user-friendly systems; (6) meet national and international standards and guidelines. Following these principles, the main treatment technologies can be classified into the following categories: (1) Primary treatments: these are physical treatments based on grid sedimentation, flotation and filtration; their objective is to remove suspended solids, coarse solids, oils, fats and decantable parts of organic matter; there is also partial removal of organic nitrogen and phosphorus and heavy metals associated with settled solids. (2) Secondary treatments: they aim to eliminate organic matter that cannot be eliminated by physical treatment and to reduce the pathogen and nutrient load; in fact, after the primary treatment, the organics can be dissolved and/or slowly settling. Thus, even if they have already been largely removed, some solids may remain in the liquid matrix (Von Sperling and Chernicharo, 2005). The degradation of organic substances occurs during biochemical reactions involving microorganisms, operating under aerobic or anaerobic conditions, which adhere to the filter media forming a biofilm. (3) Tertiary treatments: their aim is to eliminate specific pollutants, such as non-biodegradable toxic compounds; however, they are often not suitable in developing countries, as they are complicated and consume energy, which is not sustainable for local communities. Thus, the quality of wastewater treated by the Technopole's wastewater treatment plant and reused in agriculture has been assessed according to the standards of World Health Organization (WHO) and the Food Agriculture Organization of the United Nations (FAO).

II. Materiel And Methods

2.1. Materiel

The pH and temperature were measured by the pH 340i / SET meter. The conductivity and the level of dissolved solid TDS were measured by the COND 70 device. According to our results we have the following relationship: CE = 1.4xTDS. The dissolved oxygen was measured by oxi 3310 IDS Set 1. The analyzes of the parameters (TSS, COD, nitrates, nitrites) were carried out by the HACH DR / 4000v Spectrophotometer from the laboratory of the national sanitation office of Senegal. The measurements of Kjeldahl nitrogen and total phosphorus were made at the ONAS laboratory.

2.2. Methods

The WWTP was commissioned in June 2008, it performs the pre-treatment of faecal sludge recovers the liquid phase and treats the wastewater (wastewater from the liquid part of the faecal sludge and wastewater from the sewer system) by the activated sludge method (Fig.1). It is located at the Technopole, in the Grande Niaye wetland, in the Pikine department in Dakar. It is a wetland whose ecosystem is very favorable to animal life and the development of agricultural activities (Fig.2).

We have three types of collection site:

-First, the wastewater treated by Delvic entering the Technopole wastewater treatment plant. Delvic Sanitation Initiatives (DSI) is a private company that manages the collection and transport of faecal sludge from septic tanks and latrines in neighboring districts (Pikine, Cambéréne, Parcelles Assainies) which do not have a collective sanitation system (Fig.3).

-Second, the raw wastewater entering the Technopole WWTP (mixture between the Delvic wastewater and the Las Palmas pumping station).

-Finally, wastewater after treatment by the WWTP which is thrown into the lake or reused in market gardening (Fig.4).

Thus, the station receives wastewater from the pretreatment of faecal sludge from the private party Delvic Sanitation Initiatives and wastewater from the Las Palmas de Guédiawaye pumping station. About 500 m^3 of wastewater is supplied daily by the Delvic part to the WWTP and 2500 m^3 by the Las Palmas de Guédiawaye pumping station. However, the Technopole WWTP receives about 3,000 m^3 of wastewater daily, while its treatment capacity is 825 m^3 per day.

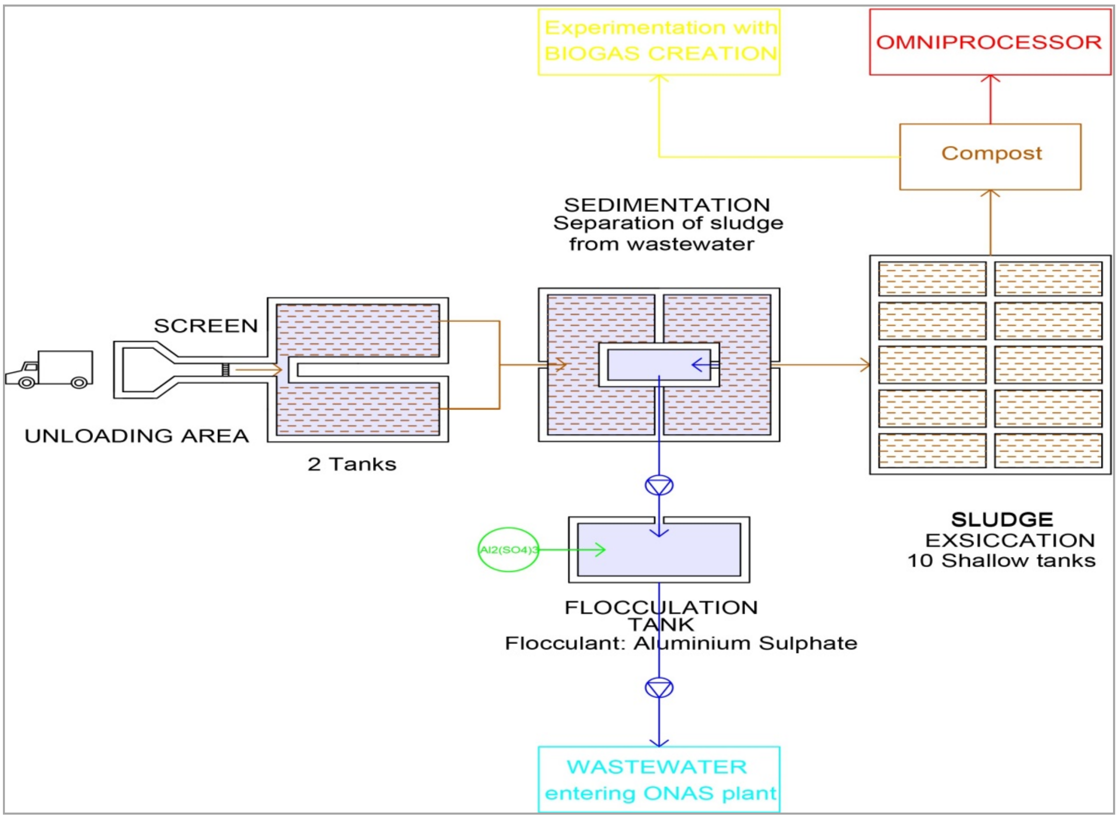

Fig.1: Diagram of the different parts of the Technopole WWTP

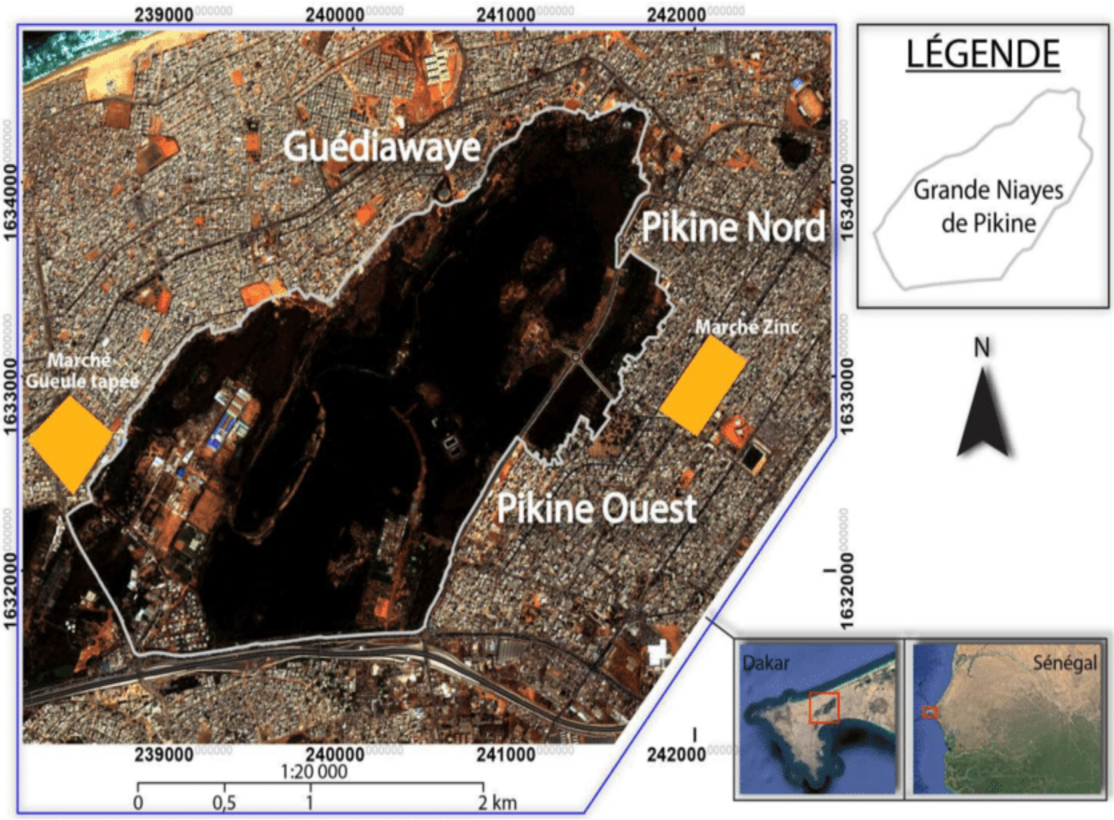

Fig.2: Location of the Technopole study area in Dakar (Diop et al., 2019)

Fig.3: Raw sewage collection and screening

Fig.4: Wastewater after treatment by the WWTP

III. Results And Discussion

3.1. Results

The results of the measurements are obtained by the average of five measurements for each of the corresponding parameters. Thus, we have the physicochemical and microbiological parameters values of wastewater from the private Delvic part sent to the WWTP (Tab.1), of the mixing between the wastewater leaving the pre-treatment by the Delvic part and the wastewater coming from the Guédiawaye pumping station (Tab.2) and the outlet treated wastewater of the Technopole WWTP (Tab.3).

From the values collected, the average values are calculated for each parameter (Tab.4) and the limit values of the parameters for the use of wastewater in irrigation (WHO, 2006) (Tab.5).

TABLE I: RESULT OF TESTS CARRIED OUT ON WASTEWATER TREATED BY DELVIC ENTERING THE TECHNOPOLE WWTP

Date	pH	Cond (µS/cm)	Salinity (mg/L)	TSS (mg/L)	BOD_5 (mg/L)	COD (mg/L)	TKN (mg/L)	PTOT (mg/L)	Faecal Col. (UFC/100mL)
07/08/2018	7.48	4630	2400	7380	1400	2520	-	-	**$8*10^5$**
13/08/2018	7.43	4310	2200	1480	650	3148	-	-	**-**
28/08/2018	7.44	4260	2200	1380	600	2840	-	-	**-**
04/09/2018	7.30	4070	2100	528	220	555	-	-	**$1.7*10^5$**
11/09/2018	7.56	3730	1900	610	800	1468	-	-	**-**
18/09/2018	7.65	4860	2600	473.3	450	1920	-	-	**-**
25/09/2018	7.61	4310	2200	527	250	1250	-	-	**-**
02/10/2018	**7.35**	**2470**	**1100**	**7340**	**1850**	**15300**	**-**	-	**-**
09/10/2018	7.41	3850	2000	920	450	2164	361.8	25.6	**-**
16/10/2018	7.43	3630	1800	640	450	2184	-	-	**$1.4*10^6$**
23/10/2018	7.39	3500	1700	1230	500	2492	-	-	**-**
30/10/2018	7.64	7.40	3680	200	450	748	-	-	**-**
06/11/2018	7.87	4490	2400	340	400	1142	663.3	12.1	**-**

13/11/2018	7.49	5150	2700	1100	600	2360	-	-	-
21/11/2018	7.41	4320	2200	700	850	1632	-	-	-
27/11/2018	**7.51**	**4430**	**2300**	**236**	**600**	**838**	**-**	**-**	**-**
Limit WHO	**6.5 - 8.5**	**<3000**		**<100**	**<400**	**<200**	**<30**	**<20**	**<1000**

TABLE II: RESULTS ON RAW WASTEWATER ENTERING THE TECHNOPOLE WWTP: MIXTURE BETWEEN WASTEWATER FROM DELVIC AND LAS PALMAS PUMPING STATION

Date	**pH**	**Cond (µS/cm)**	**Salinity (mg/L)**	**TSS (mg/L)**	**BOD_5 (mg/L)**	**COD (mg/L)**	**TKN (mg/L)**	**PTOT (mg/L)**	**Faecal Col. (UFC/100mL)**
07/08/2018	7.54	4150	2100	2340	1100	5430	-	-	**$6.3*10^6$**
13/08/2018	7.52	3110	1500	950	900	2300	-	-	**-**
28/08/2018	7.57	3990	2000	1390	800	2670	-	-	**-**
04/09/2018	7.65	3170	1600	632	700	1604	-	-	**$6.5*10^6$**
11/09/2018	7.68	2510	1200	404	650	1154	-	-	**-**
18/09/2018	7.42	1643	600	1350	800	2248	-	-	**-**
25/09/2018	7.71	4050	2100	700	400	1598	-	-	**-**
02/10/2018	**7.33**	**2420**	**1100**	**27940**	**1800**	**21840**	-	-	**-**
09/10/2018	7.51	3490	1700	868	550	1928	431.3	23.5	**-**
16/10/2018	7.52	2500	1100	360	550	2244	-	-	**10^6**
23/10/2018	7.56	2480	1100	900	750	2112	-	-	**-**
30/10/2018	7.64	2090	900	476	350	1132	-	-	**-**
06/11/2018	8.03	3720	1900	653.3	650	1337	481.4	16.0	**-**
13/11/2018	7.55	3520	1800	720	700	1724	-	-	**-**
21/11/2018	7.52	3080	1500	473.3	900	1436	-	-	**-**
27/11/2018	**7.52**	**2880**	**1400**	**524**	**1200**	**1481**	**-**	**-**	**-**
Limit WHO	**6.5 - 8.5**	**<3000**		**<100**	**<400**	**<200**	**<30**	**<20**	**<1000**

TABLE III: RESULTS ON TREATED WATER LEAVING THE TECHNOPOLE FACTORIES

Date	**pH**	**Cond (µS/cm)**	**Salinity (mg/L)**	**TSS (mg/L)**	**BOD_5 (mg/L)**	**COD (mg/L)**	**TKN (mg/L)**	**PTOT (mg/L)**	**Faecal Col. (UFC/100mL)**
07/08/2018	7.81	3310	1600	448	400	956	-	-	**$3.7*10^6$**
13/08/2018	7.75	3180	1600	540	320	1144	-	-	**-**
28/08/201	7.81	2470	110	500	320	1020	-	-	**-**

8			0						
03/09/2018	7.89	2380	1100	212	175	414,5	-	-	**-**
04/09/2018	7.87	2400	1100	520	200	603	-	-	**1.3*10^5**
11/09/2018	7.86	2460	1100	276	180	646	-	-	**-**
18/09/2018	7.93	2470	1100	228	200	627	-	-	**-**
25/09/2018	7.91	2470	1100	324	160	680	-	-	**-**
02/10/2018	**7.91**	**2440**	**1100**	**500**	**220**	**894**	-	-	**-**
09/10/2018	7.79	2470	1100	360	180	892	271	5.8	**-**
16/10/2018	7.85	2430	1100	132	200	768	-	-	**1.6*10^6**
23/10/2018	7.82	2460	1100	256	240	618	-	-	**-**
30/10/2018	7.59	3360	1700	236	180	536	-	-	**-**
06/11/2018	8.23	3580	1900	240	200	559	-	-	**-**
13/11/2018	7.90	3450	1700	264	200	33	-	-	**-**
21/11/2018	7.79	2520	1200	220	440	564	-	-	**-**
Limit WHO	**6.5 -8.5**	**<3000**		**<100**	**<400**	**<200**	**<30**	**<20**	**<1000**

TABLE IV: MEAN VALUES OF ALL PARAMETERS AT THE THREE MONITORING SITES OF THE WWTP

Parameter	pH	Cond (mS/cm)	Salinity (g/L)	TSS (mg/L)	BOD_5 (mg/L)	COD (mg/L)	TKN (mg/L)	PTOT (mg/L)	Faecal Col. (UFC/100mL)
Wastewater Delvic	7.50	3880	2.2	1568	657	2660	512.55	18.85	**790000**
Inlet wastewater	7.58	3050	1.5	2543	800	3265	456.35	19.75	**4600000**
Outlet wastewater	7.86	2740	1.3	328	238	703	271	5.8	**1810000**
Limit WHO	**6.5 - 8.5**	**<3000**	**-**	**<100**	**<400**	**<200**	**<30**	**<20**	**<1000**

TABLE V: LIMIT VALUE PARAMETERS FOR USE WASTEWATER IN IRRIGATION (OMS, 2006; FAO, 1994))

Parameters	Limit value for irrigation (WHO/FAO)
pH	6,5 – 8,5
Temperature [°C]	< 30
Suspended matter	<100

[mg/L]	
Concuctivity [µS/cm]	<3000
TDS [mg/L]	<2000
Biological Oxygen Demand BOD_5 [mg/L]	<400
Total nitrogen [mg/L]	<30
Total phosphorus [mg/L]	<20
Escherichia coli (U/100mL)	<1000

3.2. Discussion

pH

The average pH value in the wastewater entering and leaving the WWTP is between 6.5-8.5 corresponding to the range recommended by the WHO for irrigation. Furthermore, we note a slight increase from 7.58 to 7.86 after treatment (Tab.4).

Conductivity

The conductivity average concentration of the wastewater entering the WWTP is slightly higher than 3000 µS/cm, the WHO guideline value. However, we note a drop from 3050 µS/cm to 2740 µS/cm after treatment.

Total suspended solids TSS

The average content of suspended solids is 2543 mg/L in the wastewater to be treated, which is therefore very high. Despite its reduction to 328 mg/L by WWTP, it remains about 3 times greater than the limit, which is 100 mg/L for agricultural use (Tab.4). Indeed, the primary treatment is provided by a settling tank where the most important pre-treatment takes place, during which the solid part of the sludge is separated from the liquid part. Thus, due to the overload of raw wastewater from Delvic, the liquid part of the sludge leaving the settling tank was also too loaded. Consequently, a flocculation system based on the addition of aluminum sulphate as a flocculant was installed to further retain the sludge from the liquid part of the settled sludge.

Biochemical oxygen demand BOD_5 and COD

Regarding the BOD_5 concentration, it goes from 800 mg/L to 238 mg/L respectively in the wastewater entering and leaving the WWTP. Thus, it becomes lower than 400 mg/L representing the WHO limit for irrigation (Tab.4). For the average COD content of treated wastewater, there is a reduction from 3265 mg/L to 703 mg/L.

Total nitrogen and total phosphorus

Despite a reduction of 456.35 mg/L to 271 mg/L by the treatment plant, the concentration of total nitrogen is 9 times higher than that recommended by the FAO. However, that of total phosphorus is reduced to 5.8 mg/L, respecting the limit, which is 20 mg/L. In addition, this high concentration of nitrogen is probably due to the fact that the tertiary treatment consisting of a sand filter no longer works because of its overload.

Microbiological parameters

Total coliforms in wastewater went from a concentration of 4,600,000 UFC/mL to 1,810,000 UFC/mL after purification, whereas it should not exceed 1,000 UFC/mL in wastewater intended for agriculture.

Thus, the values of the concentrations of suspended solids, total nitrogen and faecal coliforms of the treated wastewater at the outlet of the treatment plant do not comply with the FAO standards for agricultural use. Indeed, it can be seen that all the values of the wastewater from the private part of Delvic sent to the treatment plant are well above the limit values for irrigation, hence the need to treat it. In addition, the wastewater data from the private part of Delvic is of better quality than when mixed with the wastewater from the Guédiawaye pumping station (Las Palmas), this is due to the pretreatment in the Delvic part of the wastewater before sending it to the treatment plant. However, the area's wastewater treatment plant receives daily quantities of wastewater that greatly exceed its treatment capacity; these practices have negative consequences on the biodiversity of the area and the health of the population (Gueye et al., 2022a, Gueye et al., 2022b). Thus, the pumping station (SP) Las Palmas de Guédiawaye supplies approximately 2,500 m^3 of wastewater per day (ONAS, 2017). In addition, 500 m^3 of wastewater is supplied daily by the Delvic part to the WWTP. Therefore, the Niayes WWTP receives approximately 3,000 m^3 of wastewater daily, while its treatment capacity is 825 m^3 per day (Bop and Gueye, 2020).

IV. Conclusion

This research aims to assess the quality of wastewater treated by the wastewater treatment plant (WWTP) in the Technopole area and reuse for irrigation. Indeed, the WWTP is undersized compared to the quantity of wastewater it receives per day. Under standard conditions, it must receive 825 m^3/d while it receives approximately 3000 m^3/d. Thus, the concentrations values of TSS, BOD_5, COD, total nitrogen and faecal coliforms in wastewater were reduced respectively from 2543 mg/L, 800 mg/L, 3265 mg/L, 456.35 mg/L and 4,600,000 UFC/mL to 328 mg/L, 238 mg/L, 703 mg/L, 271 mg/L and 1,810,000 UFC/mL at the outlet of the treatment plant. However, the parameters values of suspended solids, total nitrogen and faecal coliforms are higher than the limits recommended by the World Health Organization and Food Agriculture Organization of United Nations for irrigation (100 mg/L, 400 mg/L, 30 mg/L and 1,000 UFC/mL for the respective parameters TSS, BOD_5, total nitrogen and total coliforms). Therefore, this treated wastewater should be improved by phyto-purification which represents an appropriate technology for developing countries.

Acknowledgment

I am very grateful for the support of the research laboratory on appropriate technologies for the management of Environment in Low- and Middle-Income Countries (CeTAmb) of the University of Brescia, the National Office for Sanitation of Senegal (ONAS) and with the collaboration of Cheikh Anta Diop University of Dakar.

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