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Treatment test of oil mill effluents by a *Pistia stratiotes* L., 1753 (water lettuce) pond based system, in Maroua (Far-North, Cameroon)

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In the developing countries in general, industrial effluents are discharged into the rainwater evacuation channels, on the street, or in nature, without treatment, causing immense environmental damages. This work aimed to propose, at a pilot scale, a test treatment, based on a *Pistia stratiotes* L., 1753 pond system, to purify wastewater from the Cotton Development Company of Cameroon (CDCC) oil mill, in Maroua (Cameroon). The system consisted of two pools containing, respectively, microphytes and macrophytes constituted of *Pistia stratiotes* (water lettuce) plants. The physico-chemical characterization of the liquid waste showed that the oil mill generated, at a rate of 324 m^3/day, highly alkaline (pH = 9.77 ± 0.51), very low oxygenated (dissolved oxygen = 0.45 ± 0.09 mg/l), highly organic matter (BOD_5 = 16000 ± 6850 mg/l), nitrates (510 ± 84.50 mg/l N) and orthophosphates (5560 ± 1550 mg/l) loaded effluents. Total dissolved solids, electrical conductivity, turbidity, ammonium and nitrites presented respective mean values of 475 ± 70 ppm, 989 ± 98 µS/cm, 825 ± 94 NTU, 12 ± 2.60 mg/l and 6.50 ± 1.30 mg/l N. At the end of the test treatment, the mean reduction rates were of 26, 6, 3, 20, 94, 80, 56, 68, and 51%, respectively, for pH, electrical conductivity, total dissolved solids, turbidity, ammonium, nitrites, nitrates, orthophosphates and BOD_5, in the microphytes lagoon. These values were of 27, 48, 100, 93, 76, 71 and 57%, respectively, for pH, turbidity, ammonium, nitrites, nitrates, orthophosphates and BOD_5, in the macrophytes lagoon. Dissolved oxygen had respective increasing rates of 60 and 156%, in microphytes and macrophytes tanks.

Key words: Oil mill, effluent, lagoon, *Pistia stratiotes*, treatment.

INTRODUCTION

On the 2030 horizon, world population will increase by 3 billion people and this growth is expected, at 95%, in developing countries. Population growth will result in increased consumption needs, which will quadruple the production of wastes and effluents in cities (Farinet et al., 2004). The amount of waste will increase by 40% worldwide,

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between 2014 and 2020 (Planetoscope, 2014). It is also estimated that, each year, worldwide manufacturers dump 300 to 500 million tons of heavy metals, toxic sludge, solvents and other hazardous wastes into the sea. There are several types of wastes, including liquid waste comprising wastewater, whose release is estimated at 2000 billion litres by day (Planetoscope, 2014). However, more than 3 billion people do not have wastewater evacuation facilities (Farinet et al., 2004).

Vegetable oil mills effluents are considered among the most pollutants liquid wastes from agro-food industries (Sifoun, 2008; Ouabou et al., 2014). When released into nature or directly reused in agriculture, regardless of their quality, without treatment, they cause serious health and environmental damages (Aissam, 2003; El Hajjouji, 2007; Sifoun, 2008; Dongo et al., 2013).

In the town of Maroua (Cameroon) the solid wastes average collection, between 2008 and 2009 was estimated at 31,917 tonnes (CSRT-MUC, 2010). Similarly, the average production of plastic wastes by the population of the district of Maroua II is 337 Kg, in two weeks (Bakari et al., 2010). There are, unfortunately, very little or no statistical data on liquid wastes. Wastewater is discharged haphazardly and/or canalized into the rivers and this can have adverse effects on the environment and on the health of populations. CDCC (Cotton Development Company of Cameroon), in Maroua, in its food component, produces a cottonseed oil. The liquid waste resulting from the manufacturing process of the oil, mixed with other wastewaters, is channelled to the Mayo Tsanaga River, without any treatment.

Oil mill effluents treatment is a problem, given their chemicals quality and quantity contain (Fiestas and Borja, 1992). Indeed, the application of a single treatment is often inadequate and incomplete. Several purification systems of these effluents were tested, notably in the Mediterranean producer of olive oil basin. Treatment methods are numerous and can be classified into three categories: physical (Achak et al., 2009, 2011; Ouabou et al., 2014), chemical (El Hajjouji, 2007; Sifoun, 2008) and biological (Aissam, 2003; Achak et al., 2009, 2011; Lakhtar, 2009; Yaakoubi et al., 2009).

Water lettuce (*Pistia stratiotes*) is a plant of the Araceae family. It is native from tropical and subtropical regions, is an aquatic plant, floating in rivers, ponds, irrigation ditches, rice fields and pond systems, with long and fibrous roots suspended in the water (Iketuonye, 1987; Koné, 2002). It has, among others, the ability to purify water it colonizes (Morel and Kane, 1998; Bodo et al., 2006). Its roots capture directly their nutrients in the water.

Water lettuce has shown great potential for natural water treatment because of its rapid and easiness growth, its high nutritional value, its high capacity for assimilation of organic compounds and metals (Iketuonye, 1987; Bodo et al., 2006). The scientific basis for the treatment of wastewater by a system of aquatic plants is the growing, in cooperation, of the plants and the associated microorganisms. When microorganisms are established in the roots of plants, there is created a synergistic relationship between the two parties that results in better degradation and removal of organic compounds (Koné, 2002). *P. stratiotes* eats nitrates, phosphates and other nutrients to grow; this has the effect of removing these items from the aqueous phase (Aina et al., 2012). These characteristics lead to the use of *P. stratiotes* in the lagoon system for wastewater treating, especially of domestic origin (Fonkou et al., 2002; Koné et al., 2002; Nya et al., 2002; Kpondjo et al., 2012).

There are very few works on the purification of cotton oil mill effluents by a lagooning system and, *a fortiori*, with a *P. stratiotes* based lagoon. Therefore, this combination seems to us useful to be initiated.

The objective of this study was to develop a strategy for purifying the CDCC oil mill effluents in Maroua, by the use of a dual lagoon pools, one with microphytes and the other with macrophytes.

MATERIALS AND METHODS

Study Site

The study was conducted in the city of Maroua, the regional capital of the Far-North Cameroon. This town is located between 10°35 and 14°19 North latitude and 10°58 and 14° 32 East longitudes. The climate is characterized by the alternation of two seasons: a long dry season from October to May and a short rainy season, which extends from June to September. The rainfall amount is between 600 and 900 mm, on average. The average temperature is about 28°C; it may reach a maximum of 45 °C, during the month of April, and a minimum of 18°C, in December. The vegetation is characterized by arboreous and shrub savannah and steppes (MINADER, 2003). The city is crossed by two major rivers, with seasonal flow, generally referred to as Mayo, namely the Tsanaga and Kaliao Mayos. Soil types are essentially fersialitic soils, encountered in the foothills and ferruginous soils in the plains (MINADER, 2003).

Maroua CDCC oil mill is located in the industrial area of the Maroua I district. This district has about 450 inhabitants and is crossed by the Mayo Tsanaga River. The activities of oil, compost and animal feed production generate residues. These residues are removed in a network of liquid effluents, which converges to a collecting channel (opening outside of the plant) and flows into the Mayo Tsanaga River.

Survey

A survey was undertaken to evaluate the impact of the use of the oil mill wastewater by and on the population. To gather the views of people, we prepared a set of questions, with six issues divided into five titles: the identification of the resident (respondent), the knowledge of the CDCC outfall sewage, the mode of wastewater use, the impact on the population and the prevention and awareness. In the surrounding areas of the CDCC plant and near the discharge effluents canal, 100 people were interrogated, according to the questions set.

Characterization of the wastewater

The flow rate of the effluents was determined by evaluating the time

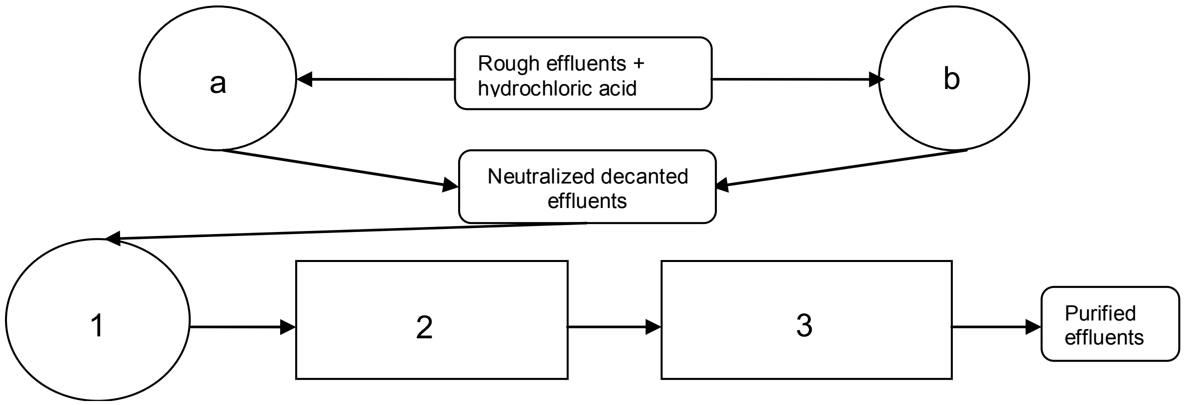

Figure 1. Lagooning system diagram. a, b, Decantation-neutralization tanks; 1, Neutralized and decanted effluents tank; 2, Microphytes basin; 3, Macrophytes basin.

needed to full a 15 l bucket by the wastewater collector canal. Elsewhere, samples were taken from manifold channel, using three sample tubes (1 l each). For general characterization, these tubes were placed in a refrigerated icebox and sent to the Hydrobiology Laboratory of the University of Yaounde I, where the following parameters were analyzed, according to the Rodier (2009) methods: BOD_5, (mg/l O_2) NO_3^- (mg/l N) and dissolved oxygen (mg/l).

pH, electrical conductivity (EC, µS/cm), total dissolved solids (TDS, mg/l)), turbidity (NTU), NO_2^- (mg/l N), NH_4^+ (mg/l N) and PO_4^{3-} (mg/l) were analyzed, *in situ*, by a Wagtech International POTALAB kit, composed of a pHmeter (Wagtech Wag-WE391655), a conductimeter (Wagtech Wag-WE393740), a turbidimeter (Wagtech Wag-WE399976) and a photometer (Wagtech Wag-WE10441).

All the measures were made in triplicate, for each parameter and in each basin, at the beginning of the treatment and after a hydraulic retention time of 5 days.

Lagooning

The CDCC oil mill wastewaters constitute a vast network of effluents of different origin (refinery, swimming pool, septic tanks and household).

The water lettuce samples were collected from the municipal lake of Yaounde (Cameroon). The samples were kept in a pool of water near a septic tank, within the plant. Before their transfer to the macrophytes basin, they were acclimated to the pre-treated effluent during 3 days.

The microphytes are constituted of local phyto (seaweed)-zooplankton witch developed in the wastewater.

To assess the purifying capacity of the water lettuce based lagoon, we used a pilot installation to simulate a reduced size lagoon system (Figure 1).

Decantation and neutralizing are the pre-treatment process in this lagooning system. Indeed, each operation has a specific role. Decantation separates the insoluble fat matter from the liquid phase. To achieve this, two half-barrels of 100 litres each are used. The rough effluents are poured in each of them and stay there for 3 days. During their stay, floating fats are removed manually, using a small container.

Neutralization is a chemical process witch importance is to make the environment favourable to the development of water lettuce (pH between 6.5 and 7.5). The effluent being basic (pH between 9 and 11), concentrated hydrochloric acid was used to neutralize the caustic effluents. After neutralization, the effluents are poured into the tank. At this level, they are ready to supply the microphytes lake, which, in turn, feeds the macrophytes basin. After the wastewaters have reached the macrophytes basin, water lettuces are introduced.

The pilot system was fed, at its input, with decanted and neutralized effluent of the oil mill, contained in a 200 L metallic cylindrical barrel, with a diameter of 60 cm and a depth of 90 cm.

Two others cylindrical metal barrels of 200 L each were cleaned, drilled and varnished. They were cut, in the length direction (depth of 30 cm) and connected, to each other, by PVC pipe (50 mm of Ø). Wastewater pass from one (microphytes basin) to the other (water lettuce macrophytes basin), by gravity. Two taps were installed, one between the tank and the microphytes basin and the other at the macrophytes basin output.

The 200 L tank is lightly raised (6% of slope) above the ground and connected to the microphytes basin. When the wastewaters reach the pipe communication in the latter, it is poured into the macrophytes basin. The excess water is removed by opening the macrophytes basin tap. The installation was carried out in the oil mill, not far from the discharge channel.

Data analysis

Data were recorded and analyzed, using SPSS 19.0 software. Comparison between the parameters amounts in the raw effluent and those in the microphytes and macrophytes ponds was made by variances analysis (One-way ANOVA), at the 0.05 level. The abatement rates of the parameters, in the ponds, were compared by the Z test, at the 0.05 level.

RESULTS AND DISCUSSION

Survey

From the questions asked to the 100 nearby residents of the study site, we obtained the following information: Concerning the knowledge of the outlet of the oil mill, of the 100 respondents, 94 argued that the outflow of wastewater from the oil mill is a river (Mayo Tsanaga), 3 thought that this outlet is a pit while the remaining, 3 people, said that, these waters are discharged into the fields and open spaces. Seas, rivers, pools and soils are

Table 1. Physico-chemical characteristics of crude oil mill effluent.

Parameter	Amounts
pH	9.77 ± 0.51
CE (µS/cm)	989 ± 98
TDS (ppm)	475 ± 70
Turbidity(NTU)	825 ± 94
NH_4+ (mg/l N)	12 ± 2.60
NO_2- (mg/l N)	6.50 ± 1.30
NO_3- (mg/l N)	510 ± 84.50
PO_4^{3-} (mg/l)	5560 ± 1550
*BOD_5 (mg/l O_2)	16000 ± 6850
*Dissolved O_2 (mg/l)	0.45 ± 0.09

*Parameters were measured after settling neutralization because the basic pH of the raw effluent is unfavourable to the activities of purifier microorganisms.

considered by industry as the best dumps (Kramkimel et al., 2004). The studied oil mill does not make exception, as it channels the effluents to a river; About the different uses made of sewage, priority goes to the recycling of fat, with 85 opinions. Dishes and laundry represented 29 views. Spreading and spraying had, respectively, 8 and 3 views. Bath, watering and drinking displayed, respectively, 4, 3 and 0 notices. Finally, other uses, including the treatment of latrines had 9 advices. The lack of water in the region is such that the residents do not hesitate to use the effluents as a source of raw material for artisanal cotton oil and soap named Garlacka production. Fortunately, they are not going to use them as a beverage, aware of their danger; Regarding the impacts of the wastewater, the proportion of people thinking that these effluents are an embarrassment is 80%. Only individuals claiming harm these waters were asked about the diseases caused by them. There were 34 respondents who believed that the use of oil mill wastewater cause skin diseases; 11, typhoid fever; 13, dysentery; 8, diarrhoea; 6, cholera; 5, Malaria and 1, diseases such as schistosomiasis and other intestinal parasites; In the area of awareness of local residents on the dangerousness of the oil mill effluent, 60 of those surveyed said they had been warned of the nuisances that may cause the use of these effluents by the competent authorities (Municipality, Regional Delegation of Environment and Protection of Nature, Administrative Division, CDCC...).

Physico-chemical characterization of effluents

Mean values of physico-chemical parameters of raw wastewater are summarized in Table 1.

The flow of wastewater from the oil mill was of 324 ± 6.51 m^3/day, which is 7 times greater than the rate of 48 m^3/day found in a cotton oil mill, in Burkina Faso (Nguématio, 1991). This flow is high and waters thus thrown out, without treatment, are destined to cause immense environmental damages.

According to Cameroonian standards of effluents discharges from industrial sources, which state, among other things, that the pH must be of 6-9, BOD_5 of 50 mg/l and total nitrogen of 10 mg/l (MINEP, 2008), the values of the parameters are very high and make these effluents extremely polluting. With a pH of 9.77 ± 0.51, these waters are very basic, probably due to the sodium hydroxide used for oil extraction. Nguématio (1991) also find a basic pH, ranging between 11 and 13, at the characterization of a cotton oil mill effluent, in Burkina Faso. A dissolved oxygen level of 0.45 ± 0.09 mg/l make these effluents very low oxygenated. The concentrations of nitrites (510 ± 84.50 mg/l) and phosphates (5560 ± 1550 mg/l) were very high and might be explained, probably, by the use of nitrogen and phosphorus fertilizers and organophosphorous insecticides in cotton cultivation (Achak et al., 2009; Gomgnimbou et al., 2009; Cotton Guide, 2014).

Treatment essay

Decantation-neutralization

Decantation separated the insoluble fatty matter from the liquid phase. The floating fats are removed manually then, using a small container.

Neutralization is a chemical process witch importance is to make the environment favourable to the development of water lettuce (pH betweens 6.5 and 7.5). During this phenomenon, the effluent pH was reduced from 9.77 ± 0.51 to 7.21 ± 0.24. Throughout the neutralization, the insoluble fatty matter separation from liquid stage is improved (Nguématio 1991).

Lagooning

Analysis of variance (one-way ANOVA) shows that, except for EC and TDS, there is a statistically significant difference between the mean values of the studied parameters in the raw effluent and those of each basin ($p < 0.05$ in each case), reflecting, a real decrease in the levels of these parameters in the lagoons.

pH varied from 9.77 ± 0.51, in the raw effluent to 7.21 ± 0.24, in the microphytes basin and to 7.09 ± 0.17, in the macrophytes pond (Figure 2A). The abatement rates obtained were, respectively, 26 and 27% for microphytes and macrophytes (Figure 5). Less than 5 or greater than 8.5, pH directly afflicts purifier organisms growth (Belghyti et al., 2009). The pH values thus obtained are acceptable to the growth of microorganisms and water lettuce, which require, generally, a pH range of 5.5 to 7.5 (Belghyti et al., 2009).

EC and TDS are related parameters. Most of the dissolved solids in the water are as electrically charged

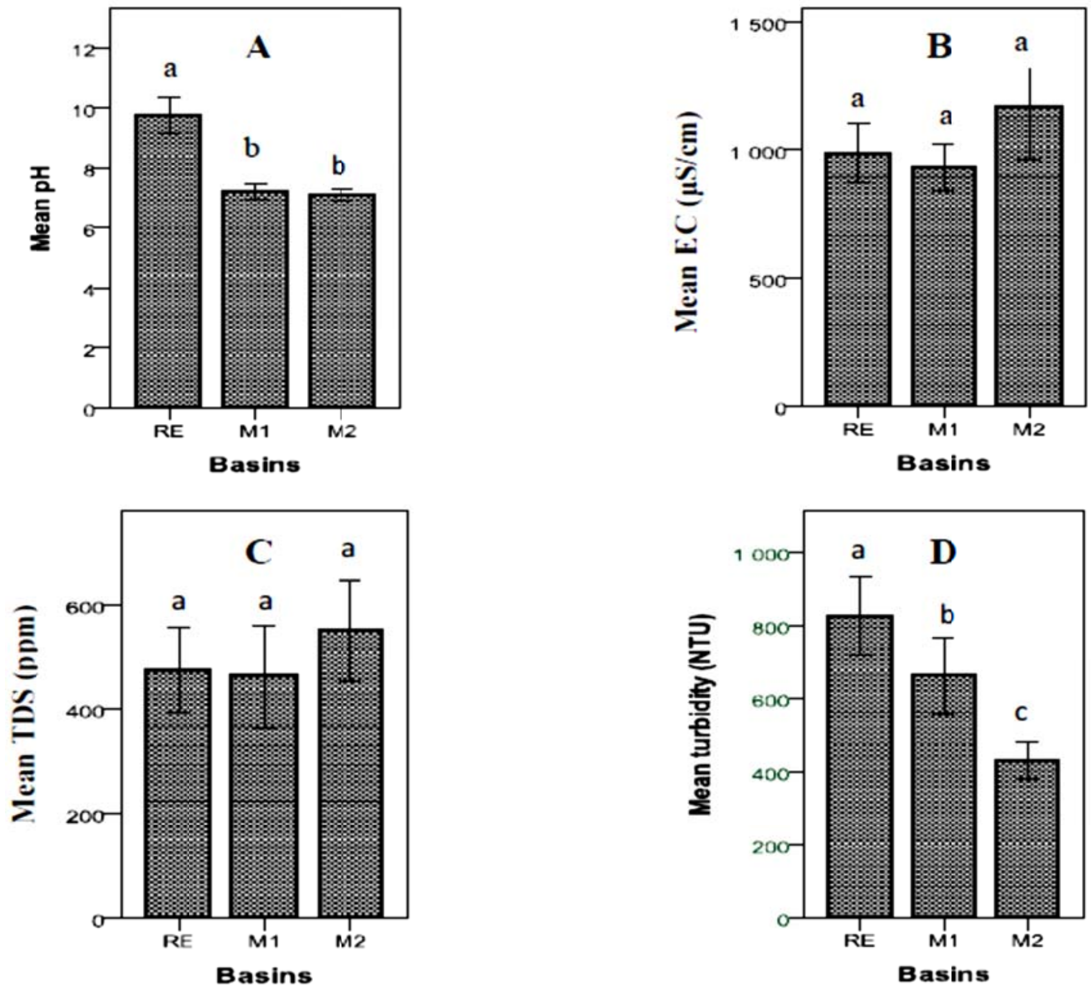

Figure 2. Mean pH (A), EC (B), TDS (c) and turbidity (D) amounts evolution, in the basins. RE: rough effluent, M1: microphytes basin, M2: macrophytes basin. In each histogram, rectangles with the same letter belong to the same group of means within which there are no statistically significant differences (Duncan test), at the 0.05 level.

ions, that determinate the EC. The behaviours of these parameters were similar. Their average values remained approximately the same, between the raw and the microphytes effluents, while they rose in the basin of macrophytes (Figure 2B and C). Likewise, Finlayson and Chick (1983), Abissy and Mandi (1999) and Tiglyene et al. (2005) show that the EC of the wastewater treated by planting Typha, Phragmites and Roseau, increases. This behaviour, with a decrease, in the microphytes basin and an increase, in the macrophytes pool (Table 2) is mitigated and is explained in different ways. This increase is, for some authors, related to evapotranspiration of vegetation, which tends to concentrate more the effluents (Finlayson and Chick, 1983; Koné et al., 2011). Ranjani et al. (1996) have linked this increase to the leaching of soil minerals and mineralization of organic matter. In our case, evapotranspiration, ions exchange between the barrel and the water and mineralization may be involved so, as well as chemical and physical mechanisms are concerned.

Turbidity translated visual presence of suspended particles, finely divided in water, clays and microscopic organisms (Menduga, 2002). Its averages significantly decreased from 825 ± 94, in the rough effluent to 662 ± 89 NTU, in the microphytes pond and to 430.33 ± 45.06 NTU, in the macrophytes lagoon (Figure 2D). Despite a reduction of 48% (Figure 5), turbidity remains high, probably because of the presence of microorganisms suspended in the macrophytes lake and the short hydraulic retention time, which would not have allowed the deposition and trapping of suspended solids by plants floating roots. Longer retention hydraulic time, may lower, the level of this parameter.

The NH_4^+ initial average grade of effluent was 12 ± 2.60 mg/l N. This decreased, in the microphytes lagoon, down to 0.67 ± 0.46 mg/l N and was reduced to zero, among

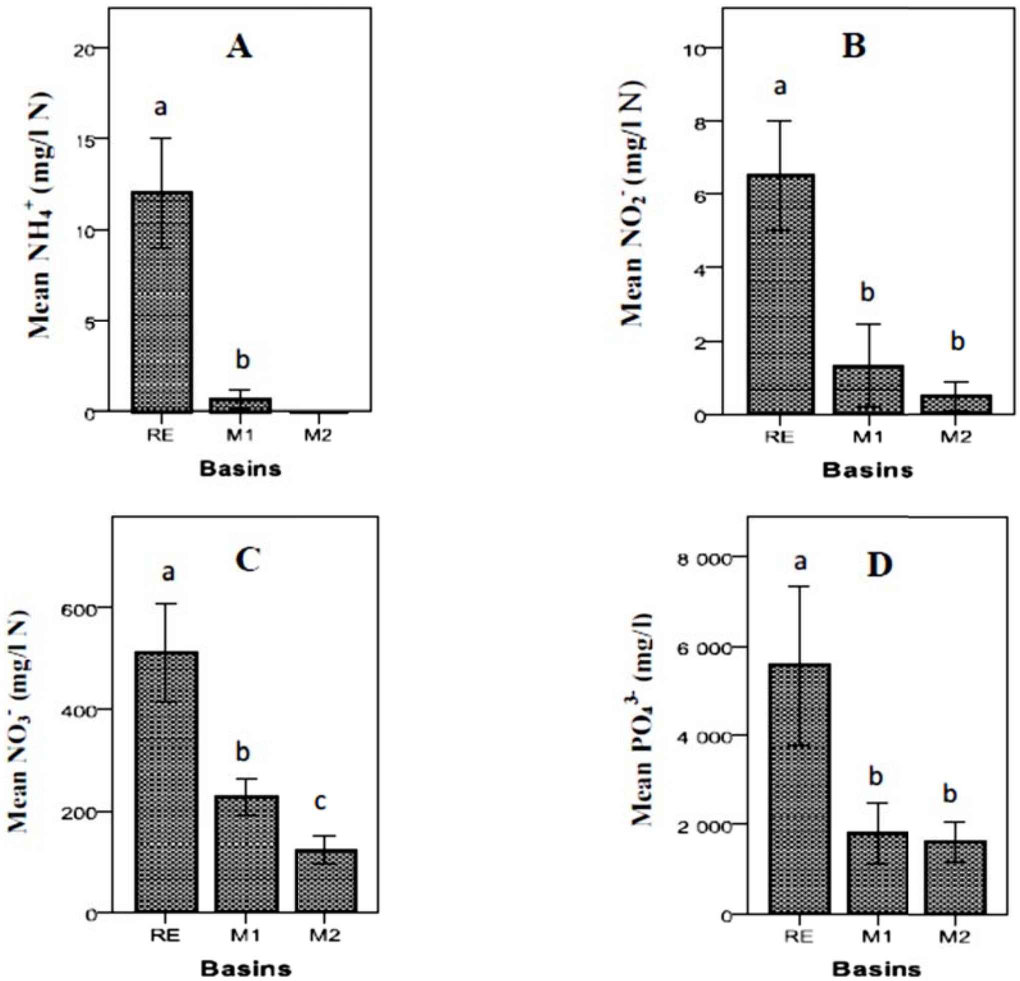

Figure 3. Mean NH_4^+ (A), NO_2^- (B), NO_3^- (C) and PO_4^{3-} (D) amounts evolution, in the basins. RE, rough effluent; M1, microphytes basin; M2, macrophytes basin. In each histogram, rectangles with the same letter belong to the same group of means within which there are no statistically significant differences (Duncan test), at the 0.05 level.

macrophytes (Figure 3A). The abatement rates were, respectively, 94 and 100%, for microphytes and macrophytes (Figure 5).

Nitrites, generally, proceed from incomplete degradation of the ammonium ions, or from nitrates reduction. Their mean concentration of the raw effluent was 6.50 ± 1.30 mg/l N, then it dropped down to 1.30 ± 0.99, in the microphytes tray and to 0.47 ± 0.34 mg/l N, in the macrophytes one (Figure 3B), inducting respective reduction rates of 80 and 93% (Figure 5).

The nitrates, relatively high average grade of raw effluent (510 ± 84.50 mg/l N), decreased to 226.70 ± 30, in the presence of microphytes and to 122.40 ± 24.50 mg/l N, in the presence of macrophytes (Figure 3C), corresponding to respective abatement of 56 and 76% (Figure 5).

The various reactions, which lead to the elimination of nitrogen in an aquatic environment, are ammonification (conversion of organic nitrogen to ammonium), nitrification (oxidation of ammonium to nitrate), volatilization (transformation of ammonium to ammonia) and denitrification (reduction of nitrate to nitrogen gas, N_2).

In the presence of aquatic plants, the main reactions of nitrogen removal are nitrification/denitrification and uptake by plants (Brix, 1997; Reddy and D'Angelo, 1997). Several studies have shown that the ammonium nitrogen form is preferably used by aquatic plants (Ower et al., 1981; Aoi and Hayashi, 1996). The presence of plants in the basin provides to the present bacterial communities a fixing support. These form a biofilm, which contributes to the degradation of pollutants. The oxygen released in this medium enables the development of nitrifying bacteria, responsible for the nitrification of ammonium. It is now accepted that nitrification/denitrification contributes largely

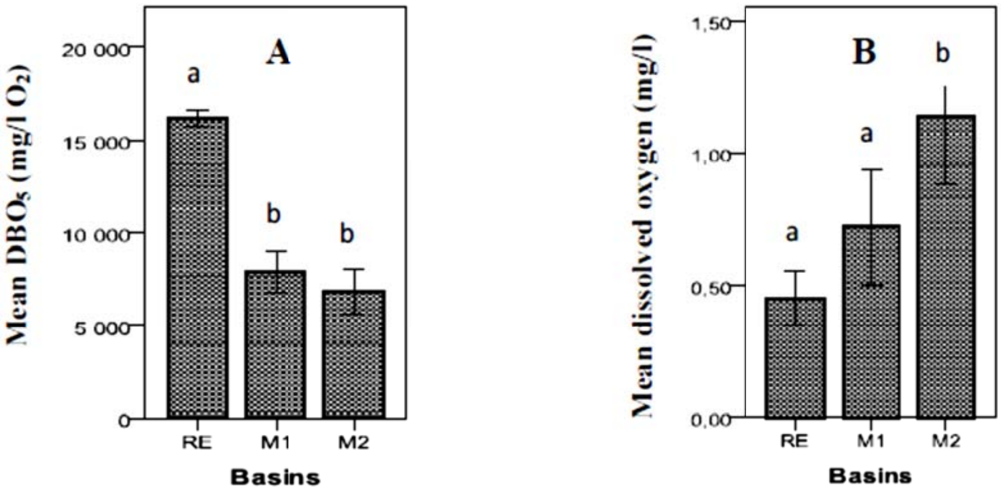

Figure 4. Mean DBO_5 (A), and dissolved oxygen (B) amounts evolution, in the basins. RE: rough effluent, M1: microphytes basin, M2: macrophytes basin. In each histogram, rectangles with the same letter belong to the same group of means within which there are no statistically significant differences (Duncan test), at the 0.05 level.

to the removal of nitrogen in ponds macrophytes (Koné, 2002). When nitrogen levels are sufficient and that the environmental conditions are favourable, nitrification-/denitrification can represent over 60% of the nitrogen lost in the basins (Bachand and Horne, 1999). The role of aquatic plants in the removal of nitrogen appears to be dominant, whether by storage in tissues or by stimulating nitrification/denitrification (Koné, 2002). From the different phenomena cited above and abatement rates obtained, we can deduce that both microorganisms and macrophytes, by uptake and trapping, are involved in the reduction of nitrogen pollutants in our purifying system.

Regarding phosphates, the average level of the raw effluent concentration was very high (5560 ± 1550 mg/l). Mean concentrations in microphytes and macrophytes lakes were, respectively, 1800 ± 592 and 1610 ± 385 mg/l (Figure 3D), giving abatement rates of 68 and 71% (Figure 5). Like nitrogen, phosphorus is an essential constituent for plant development, its availability have a direct influence on their growth. The presence of plants creates a physico-chemical environment favourable to absorption and complexation of inorganic phosphorus, which is well absorbed from the orthophosphate form in the roots and submerged parts (Koné, 2002).

BOD_5 decreased from 16,000 ± 6850 mg/l, in raw effluent to 7904 ± 969, in the presence of microphytes and 6811 ± 1056 in that of macrophytes (Figure 4A), giving respective abatement rates of 51 and 57% (Figure 5). BOD_5 is a physico-chemical parameter that estimates biodegradable organic carbon in water. In polluted environment, carbon is used by bacteria as a source of energy and for the synthesis of new cells. The removal of organic matter, in pools with floating macrophytes, is based on a symbiotic relationship between plants and bacteria, in which the bacteria use oxygen provided, to the environment, by plants during photosynthesis, to degrade organic carbon. In return, the by-products of this reaction, such as NH_4^+ and CO_2, are used by the plant (Polprasert and Khatiwada, 1998). The reactional mechanisms of BOD abatement, in pools with floating plants, are identical, for the rhizosphere, to those of fixed biomass systems and for the lower layers, to those of facultative ponds (Koné, 2002).

Poorly oxygenated, at the beginning, oil mill effluent was oxygenated more and more, as it passed through the purification basins (Figure 4B). The rate of increase in the macrophytes lagoon was 156%, reflecting thus a progressive and efficient purification (Table 2). Dissolved oxygen measured in the pools is a resultant of metabolism of plants and bacteria and of the transfer due to diffusion of air (Koné, 2002). It is also estimated that the floating plants provide 90% of the oxygen necessary for reactions of aerobic degradation in purifying ponds. Furthermore, the production of oxygen by water lettuce has been estimated between 1.4 and 2 $g/m^2/day$ (Jedicke et al., 1989).

Purifying performance

The different parameters abatement rates, according to the purifying path used, are illustrated in Figure 5. Parameters such as turbidity, nitrates, phosphates and BOD_5 showed better purification in macrophytes pond ($|Z| > Z_{0.05} = 1.960$, in each case).

These discoveries contrast, in part, with previous works. Indeed, Nya et al. (2002) find that turbidity and BOD_5 have better reduction rates in macrophytes ponds,

Table 2. Increasing rates of some effluent physico-chemical parameters, after treatment.

Parameter	Rough effluent	Microphytes	Increasing (%)	Macrophytes	Increasing (%)
CE (µS/cm)	989 ± 98	934.33 ± 78	6*	1169.60 ± 177	18
TDS (ppm)	475 ± 70	463 ± 85	3*	542.66 ± 73,80	14
Dissolved O_2 (mg/l)	0.45 ± 0.09	0.72 ± 0.19	60	1.15 ± 0.21	156

* Reduction rate.

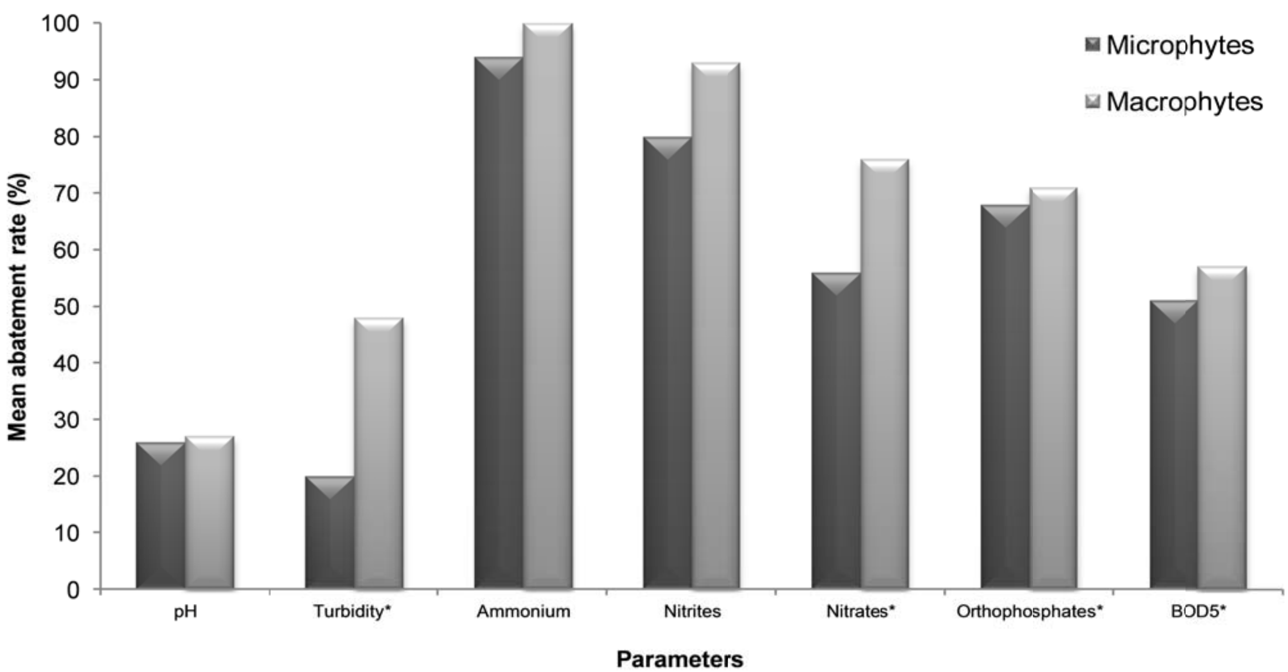

Figure 5. Parameters abatement rates, according to the used purifying path. * indicates statistically significant differences (Z test, at the 0.05 level) between the concerning parameter abatement rates.

while phosphates and ammonium are clearly reduced by microphytes lagooning. Similarly, Mandi et al. (1993) and Ouazzani et al. (1995), evaluating the comparative effectiveness of these two lagoons in Morocco, respectively, achieved a reduction of 78 and 50%, of P; 63 and 60% of NH_4^+, by the microphytes lagoon against only 26 and 37% of P; 50 and 50% of NH_4^+, by the macrophytes pond. On the contrary, Maiga et al. (2002), after a review of the abatement levels of these parameters in wastewater treatment plants by microphytes or macrophytes, in Cameroon, Burkina Faso, Senegal, Ivory Coast, Ghana and Niger, report that it would be unwise to conclude to a superior performance of microphytes or macrophytes lagoon, as the obtained results are so disparate. Koné (2002) relates the purifying performances of the two types of lagoon to their initial pollutants charges and to the order in which the basins are connected.

It was shown that macrophytes showed better performance respect to microphytes. This can proceed from the conjunction of many processes. The scientific basis for the treatment of wastewater by a system of aquatic plants is the growing, in cooperation, of the plants and the associated microorganisms. When microorganisms are established in the roots of plants, there is created a synergistic relationship between the two parties that results in better degradation and removal of organic compounds, in macrophytes system than in a microphytes one, where there are only microorganisms (Koné, 2002). Moreover, polluting particles are trapped by the plants roots and this has the effect of removing them from the aqueous phase (Nya et al., 2002).

Conclusion

In this work, a survey of one hundred individuals in the nearby of the oil mill study site was used to assess the impact of the use of these effluents by the population. It appears that these wastewaters are used for both economic contributions and agricultural household. However, these emissions are thought to cause health nuisances, like the skin, water and parasitic diseases.

A physico-chemical characterization of wastewater showed that the effluent is highly alkaline and extremely polluting, with high levels of BOD_5, TDS, EC, PO_4^{3-}, NO_3^- and turbidity.

The treatment essay of the wastewater, by combined stabilization pond (microphytes pool) and water lettuce lagoon, that ensued, allowed to display reduction rates of nitrogen compounds (ammonium, nitrites and nitrates), orthophosphates and BOD_5 upper to 50%, in each of the two ponds used, taken separately. These abatements are slightly higher in macrophytes basins. Only the pH decreased, after pre-treatment, in the range of norms required for discharges of oil mills effluents, in Cameroon. For other parameters, their initial charges were so high that, at the macrophytes tray output, their values remained important.

The achieved percentages of reduction, although very encouraging, need to be improved. It would be interesting to add filtration to the pre-treatment mechanisms, microbiological parameters to the studied elements, multiply the basins number and make them work continuously.

Conflict of Interests

The author(s) have not declared any conflict of interests.

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