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Research Article

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Contribution to improving the treatment capacity of a wastewater treatment plant in Côte d'Ivoire

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Abstract This article presents a contribution to increasing the treatment capacity of a wastewater treatment plant in Côte d'Ivoire. The objective of this study is to help improve the treatment capacity of the plant by determining the causes of downtime and poor settling and proposing solutions for improvement. The determination of the causes is made from brainstorming, observations and experimentation. The relevant causes of downtime were determined from the Pareto chart. Those of poor settling were determined from the Ishikawa diagram after monitoring the sludge indices for each basin. Finally, improvement solutions were proposed. The Pareto chart of downtime has shown that lack of space is the major cause of malfunction, causing 76.62% of total downtime. In addition, settleability was monitored. Which follow-up revealed that the sludge settling on the station is not efficient because for SBR1 about 65% of the determined sludge indices and 75% for SBR2 are above the target value 150 mL / g. The major causes identified following the analysis of poor settling are the quality of the sludge present in the basin due to fairly frequent departures of sludge (due to the sensitivity of the process) and the non-optimized management of the aeration system. Improvement solutions have been proposed such as the construction of a second buffer basin, the installation of a booster for each basin, extraction of sludge every six months and the addition of a flocculant after the biological treatment. The implementation of the proposed solutions made it possible to improve the treatment capacity of the wastewater treatment plant.

Keywords Settlement, treatment capacity, improvement, sludge index, shutdown

1. Introduction

The first stations, which initially had to meet immediate needs for the collection and treatment of industrial wastewater, are now faced with new problems [1]. In a context of continuous improvement and sustainable development, human activity seeks to optimize its constructions as much as possible, to manage its resources responsibly and to minimize its impact on the environment by reducing the pollution resulting from its activity. and waste recovery [2]. In the field of wastewater treatment, we also find this approach. This work, the theme of which is: << Contribution to improving the treatment capacity of a wastewater treatment plant on the Ivory Coast >> is part of a real development of the operating performance of the wastewater treatment plant. This study carried out in the effluent treatment plant of an agrifood industry will therefore make it possible to propose solutions with a view to increasing the treatment capacity of the existing structures of the said plant.

2. Materials and Methods

2.1. Materials

Several materials were used in carrying out this study. These include, among other things, monitoring reports, technical files, software, chemical reagents and equipment.

This equipment makes it possible to carry out analyzes of the various parameters sought.

The mixer thus made it possible to obtain homogeneous samples. The Sartorius balance for weighing chemical reagents. For analyzes, the HACH DR 2800 spectrophotometer is used to determine suspended solids, turbidity and total chlorine. The pH meter for the hydrogen potential; The oxitop® (WTW) for BOD and the HACH DRB 200 spectrometer for COD. For the assays, conventional laboratory glassware was used.

2.2. Methodology

During our study, we observed that the clarification phase in the effluent aeration basin, initially carried out in two (2) hours, could reach five (5) hours, which resulted in a reduction in the treatment capacity of the effluent. station. In addition, increasing the amount of treatment would require a reduction in the downtime recorded in the operation of the station. Analysis of the causes of stoppages in the wastewater treatment process

Reducing effluent treatment station shutdowns and optimizing clarification are increasingly seen as an essential component in increasing the treatment capacity of a treatment station (Canadian Federation of Municipalities., 2003). A study using the Pareto chart identified the causes of stoppages impacting processing capacity. The Pareto chart allows you to prioritize problematic points in order to prioritize the problems that have a more significant impact on the process.

2.2.1. Sludge settling analysis in SBR ponds

To perform the sludge settling test in the SBR basins, samples of homogeneous sludge representative of the mixed liquor (the aerator having been in operation for ¼ hour) and samples of clarified water are taken. 1L of the mixed liquor (purifying biomass + semi-treated effluent) is introduced into a 1 liter test tube. Then the mixed liquor is stirred vigorously without losing any mixture using a magnetic stirrer. Then the specimen is placed for decantation on a stable horizontal plane not subjected to vibrations, in the shade to prevent temperature rise. After 30 minutes, the volume of settled sludge is noted VD30 and this value must be between 100 and 300 mL. Otherwise, the test tube is emptied of its contents and is rinsed. Then 500 mL of sludge and 500 mL of purified effluent which corresponds to a dilution of ½ are introduced into the test tube, the procedure is carried out in order to determine the volume of sludge settled in thirty minutes [3]. The sludge index (IB) is expressed in mL.g-1 of MES, and is defined by the following formula:

$$IB = \frac{VD_{30}}{MES \times f}$$

With: VD30: volume of sludge settled in thirty minutes (in mL.L-1); SS: concentration of suspended solids in the test tube (in $g.L^{-1}$); f: the dilution factor equal to ½.

2.2.2. Application of the Pareto chart in the search for the causes of stops within the station

Also known as the 20/80 law, the Pareto diagram is useful for identifying which causes to act as a priority to significantly improve the situation (reduce as much as possible the downtime of the purification process). This will avoid wasting energy on things that have little impact. This is a bar chart with the values listed in descending order. The main steps in the development of the Pareto chart are as follows:

- ✓ Collect data Place values in a table
- ✓ Sort values in descending order
- ✓ Calculate the cumulative percentages
- ✓ Establish the graph

2.2.3. Application of the ISHIKAWA diagram in the search for the causes of poor settling

It consisted in investigating the causes of poor sludge settling from the ISHIKAWA diagram. The construction of the Ishikawa diagram is based on group work; it is developed in several stages which consist of:

- ✓ clearly describe the problem;
- ✓ determine by brainstorming all the possible causes linked to the problem so that everyone freely gives their opinions on the possible origins (never criticize the ideas of others, even suggestions without any realistic basis are necessary);
- ✓ classify the causes into large families: by enlisting the help of the 5Ms who are the most used as starting points for reflection and then placing them on the skeleton of the Ishikawa diagram
- ✓ carry out a new reflection by approaching the problem axis by axis; - determine the relative impact of each cause on the effect, (Expert judgment). This is to determine the likely causes of the effect. This step can possibly be done by a vote [4].

3. Results

3.1. Results of the analysis of stops recorded within the station

The main causes of treatment station shutdowns were identified from the available data. Table 1 lists the causes responsible for the outages, listed in the total downtime as well as the representative percentage.

Table 1: Percentage of downtime by cause

Cause linked to the shutdown of the wastewater treatment plant	Station downtime (minutes)	% stop	Cumulative %
Lack of space (buffer basin filled)	5785	76.62	76.62
Clogged piping	850	11.26	87.88
Reactive tank stirrer	365	4.83	92.71
Feed pump	310	4.10	96.81
Reagent dosing pump	240	3.18	100
Total	7550	100	

Pareto's law or the law of 20/80 states that 20% of the causes are responsible for 80% of the effects. The plot of the Pareto chart of the downtime within the station is given in Figure 1.

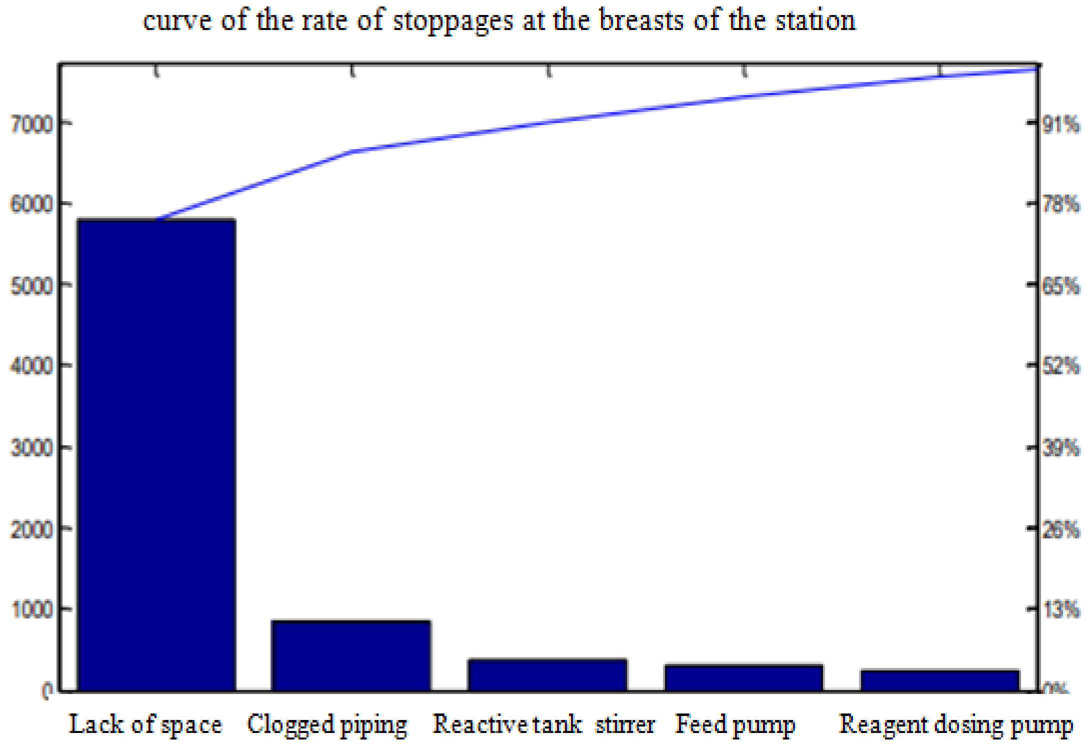

Figure 1: Pareto chart for the causes of effluent treatment plant shutdowns

The Pareto chart of downtime as a function of malfunction categories, shows lack of space as the single major malfunction (76.62%) of total downtime. Attention to this cause would help improve treatment capacity. This increase in treatment capacity will thus make it possible to cope with a possible intensification of effluent-generating activities.

3.2. Results of sludge settling analysis: sludge index

The settling tests carried out over the period from June to September 2021 on the two activated sludge tanks made it possible to obtain the results presented in Table 2 and illustrated in Figure 2.

Table 2: Settling index or sludge index of SBR1 and SBR2

Period	03-juin	16-juin	01-juil	17-juil	05-août	18-août	02-sept	16-sept	average
IB 1	163	145	120	151	154	144	153	169	149,875
IB 2	184	151	139	145	176	189	203	220	175,875
Cible	150	150	150	150	150	150	150	150	155

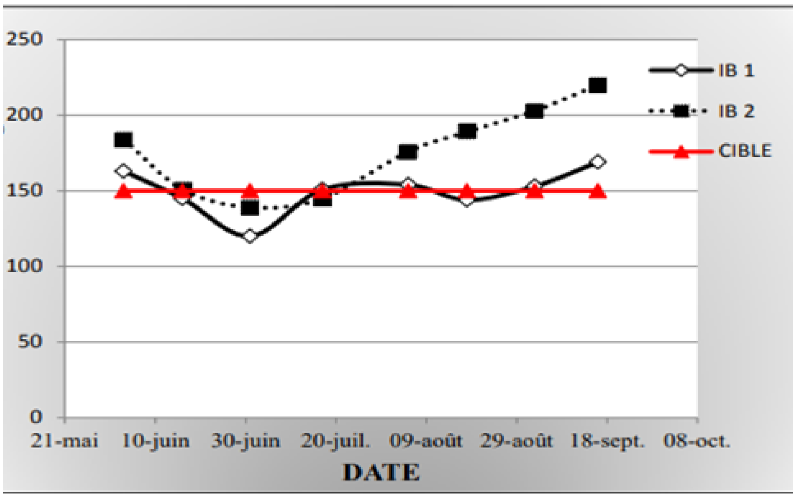

Figure 2: Settlement index of diluted activated sludge

Sludge settling on the WWTP does not seem very efficient because for SBR1 around 65% of the sludge indices determined and 75% for SBR2 are greater than the target value 150 mL / g; Indeed, during this period, the IB fluctuated between 120 to 170 mL / g with an average value of 150 mL / g for pool no.1 and between 140 to 220 mL /g with an average value of 176 mL/g for pool n °2. This change in the behavior of the sludge is a highly penalizing element for this type of operation, especially since we want to minimize the settling time in order to increase the treatment capacity of the station. Several factors can explain the poor aptitude of sludge for settling. Mention may be made, for example, of the loss of purifying biomass generated by leaching during the emptying stages. These factors have been grouped together in the Ishikawa diagram in Figure 3.

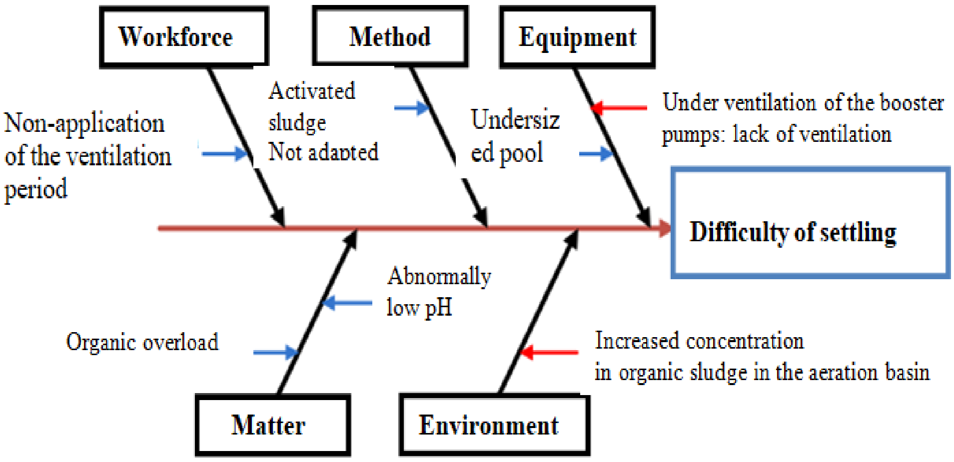

Figure 3: Ishikawa diagram for the causes of the settling difficulty Method

Thus, from a physical point of view, the crucial problem which makes settling in SBR basins difficult is on the one hand the quality of the sludge present in the basin due to fairly frequent departures of sludge (due to the sensitivity of the process) and on the other hand, inadequate management of the ventilation system. Thus ways and means for the optimal management of the aeration system, and an efficient management of sludge management according to the suitability of the mixed liquor to settle are exposed in the section of proposed solutions.

3.3. Proposal of improvement solutions

Improving the hydraulic performance of the station requires an effective response to the causes of the various design and technical malfunctions observed. We recommend:

- ✓ The construction of a second buffer basin. This will prevent long stops in the treatment process and consequently increase the treatment capacity of the structures.

To improve settling, the choice of aeration system is very important, so some recommendations should be taken into account:

- ✓ Install one booster per tank when the two tanks are in service,
- ✓ Extract the sludge every six months to obtain younger sludge, more settable in order to reduce oxygen requirements;
- ✓ Add, as a last resort, a flocculating agent to improve settling.

4. Discussion

This study showed that the sludge indices are high for the two basins (SBR1 and SBR2). In fact, more than half of the sludge indices are located above the target value 150 mL / g (for SBR1 approximately 65% of the sludge indices determined and 75% for SBR2 are greater than the target value 150 mL / g). This explains the poor settling. One of the probable causes revealed in our study is the loss of purifying biomass caused by leaching during the emptying stages. These results are consistent with those of the authors [5] who have shown that, when the sludge index is high, poor settling is caused by ecosystem disorder. One of the major causes of the insufficient settling identified in this study is the inadequate management of the aeration system. Indeed, the aeration of treatment basins plays a very important role in improving the performance of a wastewater treatment plant. These results are supported by the work of Mahmoud, *et al* [6]. This concluded following that the organic matter expressed in COD was eliminated up to 58.35% and 81.11% respectively for the columns without and provided with a central and peripheral ventilation system. The ammoniacal nitrogen abatement yields were 74.11% and 92.14%, respectively. The more the gas phase of the medium is renewed, the better the treatment capacity.

5. Conclusion

This work was carried out with a view to continuously improving the performance of the industrial effluent treatment process. The surveys, brainstorming and analyzes were carried out within the agro-food industry effluent treatment plant in Côte d'Ivoire.

Two essential points were discussed, namely the causes of process downtime and those of poor settling. The search for the causes was carried out on the basis of surveys, brainstorming, observations and experimentation. Pareto and Ishikawa charts were used to assess the impact and relevance of causes related to downtime and poor settling, respectively. The Pareto chart of downtime has shown that lack of space is the major cause of malfunction, causing 76.62% of total downtime. Settlement (sludge index) was monitored. Which follow-up revealed that the sludge settling on the station is not very efficient because for the SBR1 about 65% of the determined sludge indices and 75% for the SBR2 are above the target value 150 mL / g. The major causes identified following the analysis of poor settling are the quality of the sludge present in the basin due to fairly frequent departures of sludge (due to the sensitivity of the process) and the non-optimized management of the aeration system. Improvement solutions have been proposed such as the construction of a second buffer basin, the installation of a booster for each basin, extraction of sludge every six months and the addition of a flocculant after the biological treatment.

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