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Optimization of Water for an Electricity Power Station

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Abstract
The objectives of this paper are to optimize water used in thermal power station, study the possible opportunities for conservation of water used in the power station recycle and reuse the waste water in power station.
Thermal power plants in Sudan contribute 40% of the total electric power generation in Sudan. The experimental year was divided to three seasons. Samples of waste water were taken from different points at the power station in every season. All samples were analyzed and results were written and discussed. Solutions for reuse of the waste water inside thermal power stations were suggested.

Keywords: Optimization, Cooling Water, Electricity Power Station.

1. Introduction
There are several types of water found in the power station, all of different quality and composition. Water is contained within the boiler drum and steam generation tubes and headers. It is converted into steam to produce mechanical and then electrical energy within the turbine.
The water is also used for the condensers, air coolers and oil coolers. It is circulated through the heat exchangers by the main cooling water (C.W) Pumps and back to the cooling tower where the water is cooled by the cooling tower.
There are three big thermal power plants in Sudan of total capacity of 1330 MW. This paper concentrates on the optimization of water in the power plant by the reuse of waste water after treatment. Waste water treatment plants are designed to convert liquid wastes into an acceptable final effluent and to dispose of solids removed or generated during the process.

2. Thermal Power Plants in Sudan
Thermal power plants in Sudan are either in the national grid or in the isolated grids in many towns. The biggest thermal power plant station is of total capacity of 560 MW. It is composed of 4 blocks of combined cycle units, each consists of two gas turbines and one steam turbine, another two steam turbines work with sponge coke fired boilers. The second bigger thermal power plant contains 6 steam turbines of total capacity of 380 MW power generations. The case study of this paper will focus on the second power plant. The other power plants are small diesel generating units scattered in many towns.

3. Power Station Features
Khartoum North Power Station is located east of Khartoum North industrial area. The main features of this location are:-
1. Near to the power consuming areas.
2. Closeness to the road and railways.
3. Closeness to distribution and transmission station.
4. Next to the water source (Blue Nile).

4. Test Methods
The filterable and non filterable matter in Water in mixed sample is filtered through a weighed standard glass fiber filter. The suspended solids are retained on the filter, which is dried at 105 °C and weighed. The increased mass on the filter represents the non filterable matter. The filtrate may be used to determine the filterable matter. The filtered sample

(liquid phase) is evaporated to dryness and heated to 180 °C in a tarred vessel to a constant weight. The Oil and Grease in the Water Sample is brought into the laboratory. Either sample bottle is to be marked at the water meniscus or the bottle to be weighted, for later determination of sample volume. The sample is transferred to a separator funnel. The sample volume is calculated by the difference from the initial weight. The chemical Oxygen Demand (COD) test predicts the Oxygen requirement of the effluent and is used for monitoring and control of discharges. It is also used for assessing the treatment plant performance. In the plainest (COD) method, the water sample is oxidized by digesting in a sealed reaction tube with sulphuric acid and potassium dichromate reduced in proportion to the (COD). A reagent blank is prepared for each batch of tubes so as to compensate for the oxygen demand of the reagent itself. Over the range of the test a series of colors from yellow through green to blue are produced. The color is indicative of the chemical oxygen demand and is measured using a plainest photometer. The results are expressed as milligrams of oxygen consumed per liter of sample and the Biochemical Oxygen Demand is expressed as weight of oxygen consumed per unit volume of water during a defined period of time at a defined temperature.

5. Sampling

Six samples of waste water was collected (1+0.5) liter. They are explained in the flow sheet of sample point at the power station Figure (1).

- Sample (1) from the river side before the pre-treatment.
- Sample (2) from the river side after the clarifier.
- Sample (3) from the power station after the final treatment.
- Sample (4) from the power station before the clean drain.
- Sample (5) from the power station after the clean drain.
- Sample (6) from the river side after the sludge sump.

Flow sheet of sample point in the power station

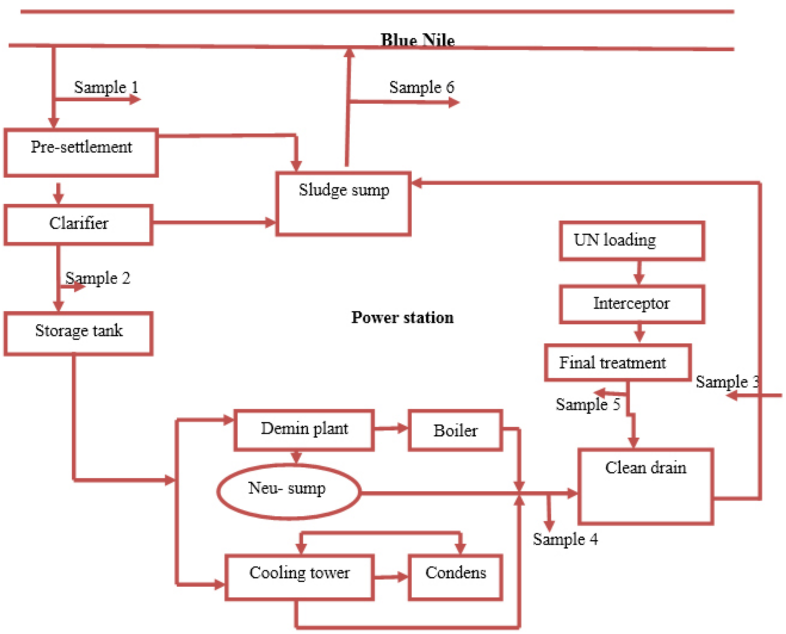


Fig 1: Flow sheet of sample point in the power station

6. Results

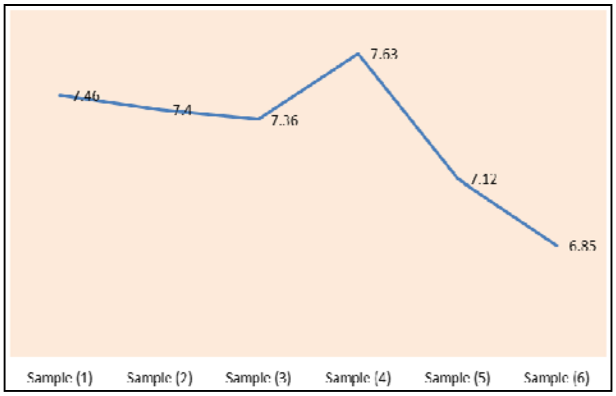
The year for the experimental work was divided into three Periods. The first one is winter season (from October to March), the second one is summer season (from April to June) and the last one is autumn season (from July to September). For every period a material balance about the consumption of water was carried out.

The result of third frequency

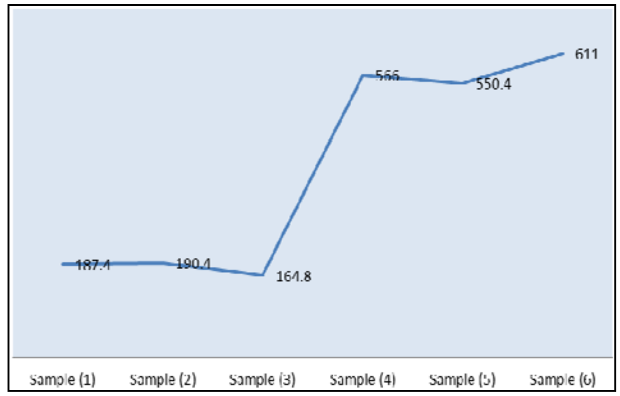
The third period is autumn season (from July to September). Table (1) shows the result of the third frequency. Seven graphs are plotted to indicate the six samples values for the parameters (PH, conductivity, turbidity, total hardness, T-D-S, T-S-S, oil and gas).

Table 1: the result of the third frequency

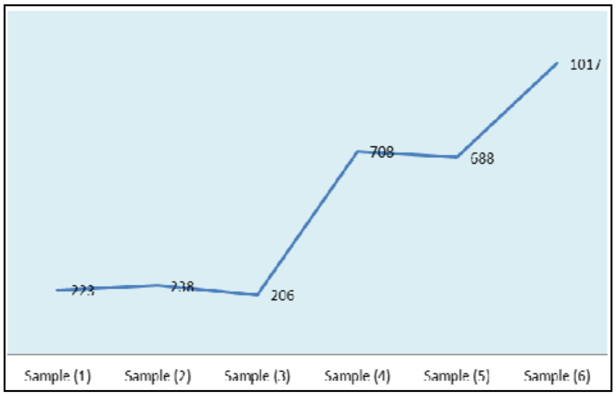
Test	Sample (1)	Sample (2)	Sample (3)	Sample (4)	Sample (5)	Sample (6)
pH	7.46	7. 4	7.36	7.63	7.12	6.85
Conductivity	223.0 us/cm	238.0 us/cm	206.0 us/cm	708 us/cm	688 us/cm	1017 us/cm
Turbidity	4665 NTU	4.84 NTU	22.0 NTU	5.43 NTU	3.07 NTU	1996 NTU
Total Hardness	68.0 ppm	78.6 ppm	93.0 ppm	300 ppm	262 ppm	300 ppm
T-D-S	187.4 ppm	190.4 ppm	164.8 ppm	566 ppm	550.4 ppm	611 ppm
T-S-S	3.52 ppm	0.03 ppm	0.03 ppm	0.01 ppm	0.009 ppm	28 ppm
Oil and Grease	0.00 ppm	0.00 ppm	0.2 ppm	0.048 ppm	0.036 ppm	0.11 ppm
COD	-	-	-	-	-	82 ppm
BOD	-	-	-	-	-	48 ppm



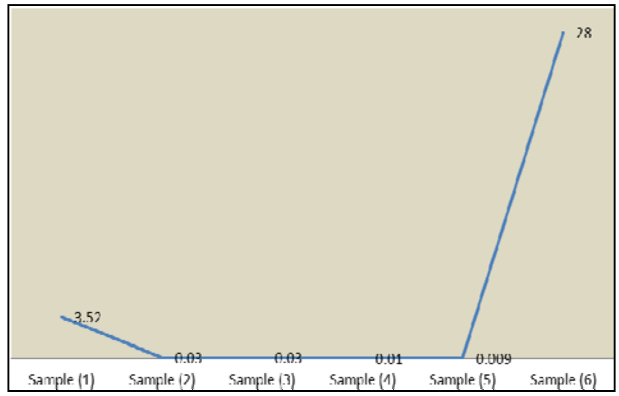
ph



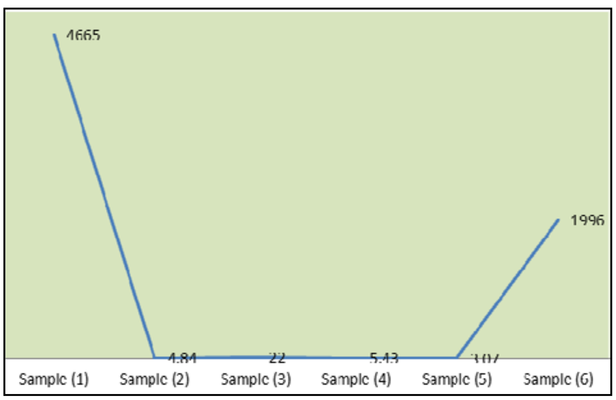
T-D-S



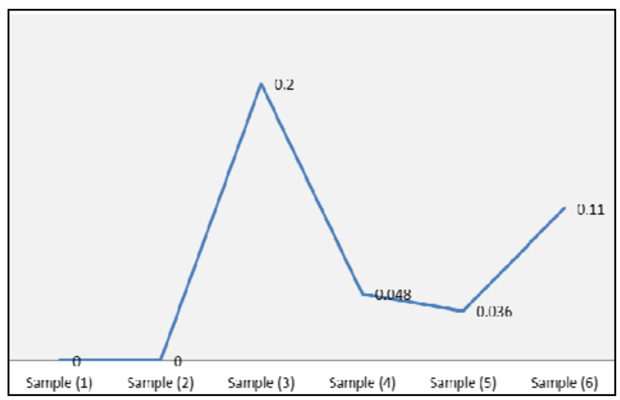
Conductivity



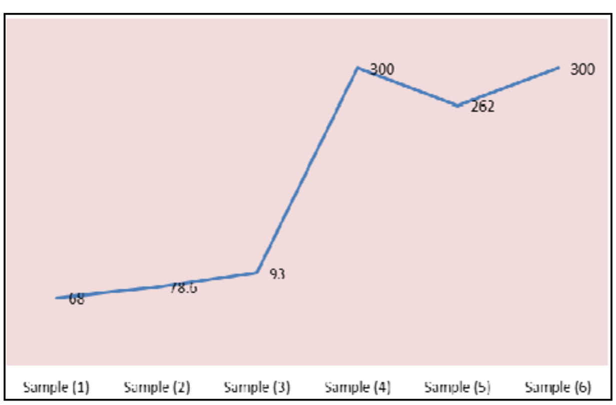
T-S-S



Turbidity



Oil and Grease



Total Hardness

7. Material Balance

Material Balance of the third frequency (autumn season from July to September) is shown in Table (2).

Table 2: Material Balance

Item	Input m^3/h	Output m^3/h	Loses m^3/h
Demin plant	50	48.8	1.2
Cooling tower	230.4	165.6	64.8
Clean drain	165.24	180	-14.76
Sludge sump	238.32	272	-33.68
Total	683.96	635.6	17.62

8. Discussion

Based on the obtained results, the following points are observed:

- In all seasons throughout the year, the water quality in autumn season was within the standard specifications for treated water and waste water.
- For sample 6 which is the sample of water returned to the river, additional analysis for the COD, BOD were carried and the results obtained were within the acceptable limits according to the Sudanese Specifications.
- Material balance was done seasonally to determine the produced waste water, the water quantity used in the power station, and the water returned to the river. Table (2) shows the water entering to every unit in the power station, the water that flows out of the unit and the loss of water in each unit.

9. Conclusion

The following conclusions are drawn from the above results and discussions:

In autumn (flood season), the results are within the standard specifications for treated water and waste water. The results of the COD, BOD for sample 6 (which is the sample of water returned to the river) are within the acceptable limits.

In the autumn season (from July to September), the high turbidity is reflected in high consumption of chemicals. The calculated Dilution Factor in the Blue Nile throughout the year in this study area was very high, and the remaining returned waste water in the bottom of the clean drain basin is recommended to be used in the irrigation of trees surrounding the power station to screen out the exhaust gases so as to make the environment around the power station clean and free from pollution.

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