The study of physico-chemical characteristics of power plant effluents at Basrah governorate.

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Abstract-The present study was conducted on Najibia and Hartha power plants to assess the physico-chemical characteristics of power plant effluents and to investigate the environmental impact resulting from them. The water samples from both power plants were collected for four weeks during Summer season in 2012 where water samples were taken from three sites (Inlet water, outlet cooling and outlet Industrial water) for analyzing seven parameters (water temperature, pH, electrical conductivity, total suspended solids, chloride, total phosphorus and total iron). Water temperature increased at site 2 (outlet cooling water) comparable with site 1 (inlet water) at Najibia and Hartha power plants, at Najibia power plant it exceeded Iraqi guideline value of waste effluents (< 35 °C) while at Hartha one it was within that guideline. pH values of the sampling sites at both power plants were found to be neutral to alkaline in nature, pH value of site 1 was within the Iraqi guideline value of surface water (6.5-8.5) and the effluents of both site 2 (outlet cooling water) and 3 (outlet industrial water) were within the Iraqi guideline value (6-9.5) of waste effluents which had no effect upon aquatic organisms. Electrical conductivity elevated at site 2 at Najibia power plant due to high temperature while at Hartha power plant, water electrical conductivity of site 2 was lower than that of site 1, the electrical conductivity result of site 3 at Najibia power plant was higher than that of site 1, and at Hartha power plant it was lower than that of site 1. The highest average of suspended solids was at site 3 in Najibia power plant comparable with other sites while at Hartha power plant the least average of suspended solids was at site 3 comparable with the other sites. However, the effluents of both site 2 and 3 at both power plants did not exceed Iraqi guideline value (60 mg / l) of waste effluents. The average values of chloride ion for site 1 and 2 at both power plants were less than 1000 mg/l and this indicated that river water was suitable for cooling purpose while the average chloride's ion values of site 3 at both power plants were within the Iraqi guideline value (600 mg/l) of waste effluents where they did not threaten the life of aquatic organisms. The prevalence of phosphorus compounds in industrial wastes referred to water treatment processes and the results of all sampling sites at both power plants were very high to produce eutrophiction phenomenon where it occurs in an aquatic environment when concentration of orthophosphorus is only 0.005 to 0.05 mg/l .The average values of total iron at site 1 did not exceed the guideline value (1 mg/l) of U.S. Environmental Protection Agency (1986) for freshwater aquatic life. Where as the concentrations of total iron in site 2 and site 3 at both power plants were within the Iraqi guideline value of waste effluents (2 mg/l).

Key word: power plants – effluents- aquatic environment – guideline values.

1. Introduction:

Power plants affect the environment in various ways, as do all industrial factories like air pollution by the emitted gases and smog which leads to acid rain and global warming and the large volumes of withdrawing water for cooling purpose in once-through steam power plant which then discharged back into water bodies affecting aquatic organisms (1) in addition to discharge of liquid wastes into aquatic environment without adequate treatment (2). Along the world, there are several types of power plants, steam – gaseous - coal - nuclear. At Basrah governorate, there are two steam power plants and two gaseous ones, the present study was conducted on Najibia and Hartha power plants both them are steam ones in which both hot cooling water and the waste effluents present the virtual danger that threatened the aquatic life (3). So, the objective of the present study is to assess the physico-chemical characteristics of power plant effluents at Basrah governorate depending upon Iraqi and international standards and investigating the environmental impact resulting from them.

Many studies overall the world have demonstrated the influence of the power plant effluents on aquatic life. Fang et al., (1) investigated how thermal effluents of two nuclear power plants located at Huang Chi river in Taiwan affected marine ecology, Demirak et al., (4) studied ground water pollution with trace metals at wells located near Yatagan thermal power plant in Turkey, Junshum et al., (5) studied the composition of algal communities in area located around Mae Moh power plant. Choi et al., (6) had studied copepods (zooplankton) mortality resulting from thermal impact of a coal power plant located at Young-Heuny in Korea. In Iraq, several researchers have been studying the power plant wastes like Mahdi et al., (3) who assessed the industrial wastes produced by Al-Dora and Baghdad South Electric power plants while Mohammed and Mahmoud (2) suggested re-using the boiler blow down of thermal power plants after treated it by demineralization process. At Basrah governorate, Al-Sabah (7) investigated of pollution level near Najibia and Hartha power plants, Hussein et al., (8) investigated the impact of Hartha power plant on the abundance and distribution of algae and Hassan et al., (9) demonstrated the levels of several pollutants near Najibia and Hartha power plants.

2. Experimental:

2.1. Description of the study area:

Water sampling was conducting on both Najibia and Hartha once-through steam power plants located at Hartha district north of Basrah as shown in figure1.

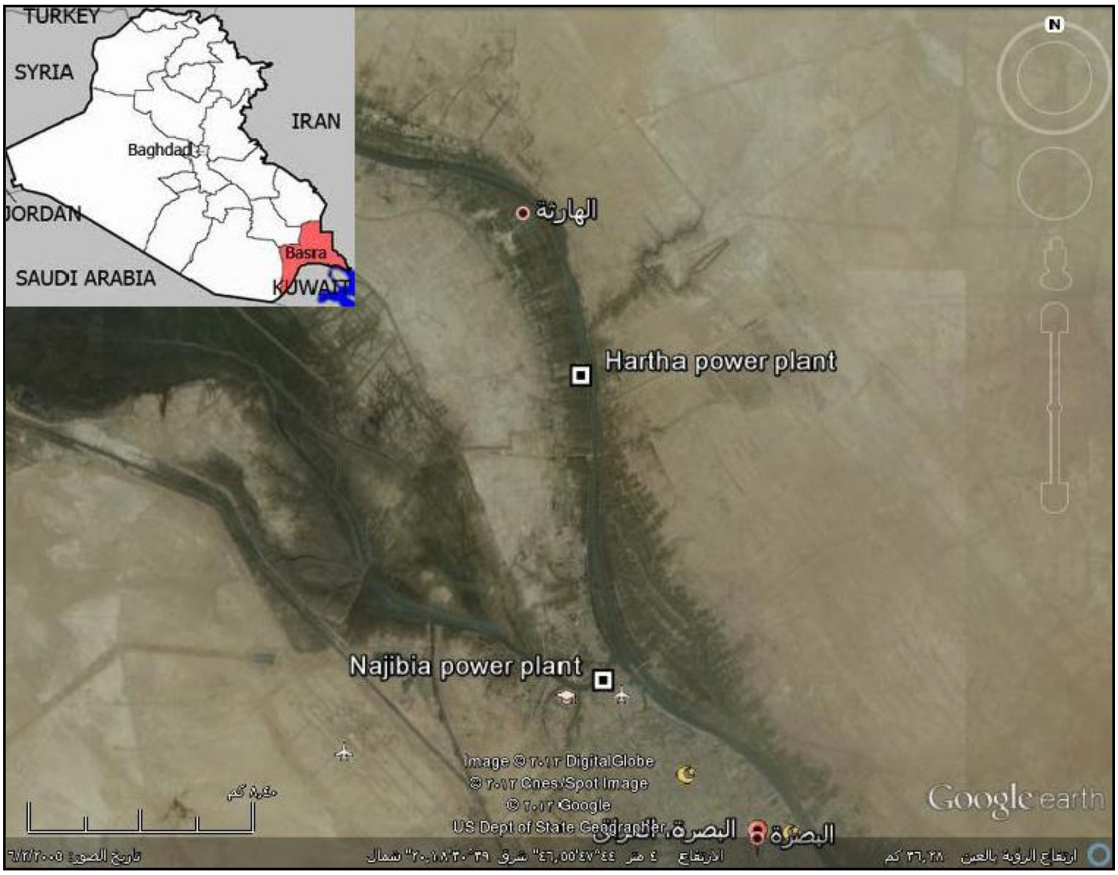

Figure 1: map of the southern part of Iraq (Basrah) showed the study area.

Any steam power plant consists of the following main parts as shown below in figure 2 they are : 1) furnace, 2) boiler, 3) turbine, 4) generator, 5) condenser, 6) chimney and 7) and other auxiliaries (10 , 11). In its operation, the combustion of fuels in furnace supplies heat to produce steam inside the boilers, which is used to generate mechanical energy in a turbine; this energy is subsequently converted by a generator to electricity. Many liquid wastes are discharged continuously as long as the plant is operating; these include waste waters from the following sources: cooling water systems and boiler blow down (industrial wastes) while wastes resulting from water treatment, for feeding boiler with pure water, are produced at regular intervals (11). In the present study, the water samples from both power plants were collected for four weeks during Summer season in 2012 where water samples were taken from three sites, as shown in figure 2, they are:

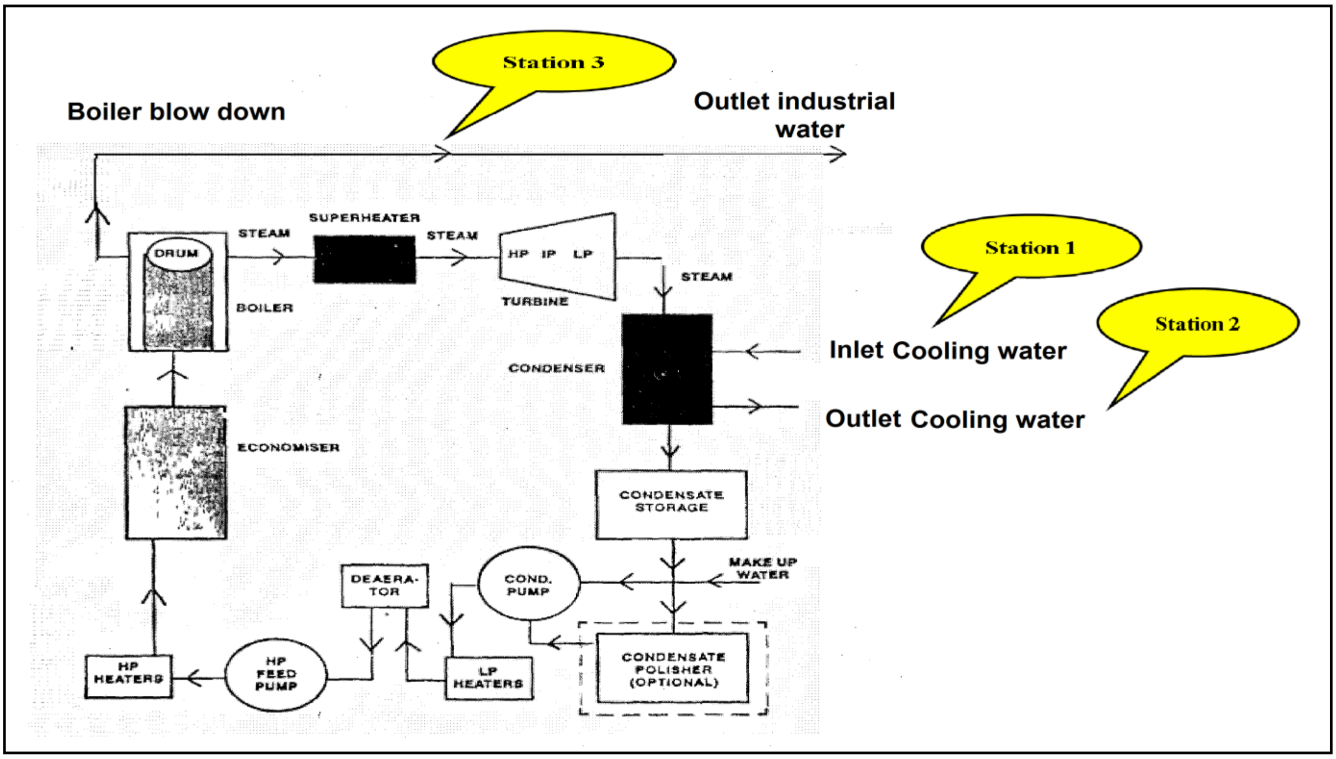

Figure 2: Schematic diagram of once-through steam power plant showed sampling sites.

1- Inlet water (raw water) which withdrew from river.

2- Outlet cooling water and,

3- Outlet Industrial water discharged into river At Najibia power plant while boiler blow down pit at Hartha once.

2.2. Material and methods:

After sampling, from the formerly mentioned sampling sites, water samples were analyzed at situation for several parameters with multimeter Horiba model W-2030 MFG. NO.812003, they are: temperature, pH, electrical conductivity then taken to the laboratory to complete the remained physico-chemical analyses which included total suspended solids, chloride, total nitrogen, total phosphorus and total iron. Total suspended solids were determined gravimetrically according to APHA (12), chloride was determined by titration according to APHA (12), total phosphorus (orthophosphate, polyphosphate and organophosphate) was colorimetrical determined at 880 nm after digestion with acid per sulfate method according to APHA (12) by PU 8670 VIS / NIR spectrophotometer apparatus and finally total iron was also colorimetrical determined at 510 nm according to APHA (12).

2.3. Statistical analyses:

For demonstrating the spatial and temporal variations of the sampling sites at both Najibia and Hartha power plants, ANOVA test of variance was achieved using SPSS v.18.0.

3. Result:

3.1. physico-chemical characteristics for the studied sites:

3.1.1. Water temperature:

Water temperature of both Najibia and Hartha power plants are illustrated below in figure 3. At Najibia power plant the statistical analysis showed highly significant spatial variations in water temperature ($p < 0.001$) among the sampling sites where the highest mean was registered at site 2 (outlet cooling water) which differed from the other sites. Also at Hartha power plant, there were high significantly spatial variations in water temperature ($p < 0.001$) among the sampling sites where the highest mean was registered at site 3 (boiler blow down pit) which significantly differed from site 2 (outlet cooling water) while the least mean was registered at site 1 (inlet water) which significantly differed from site 2 and 3.

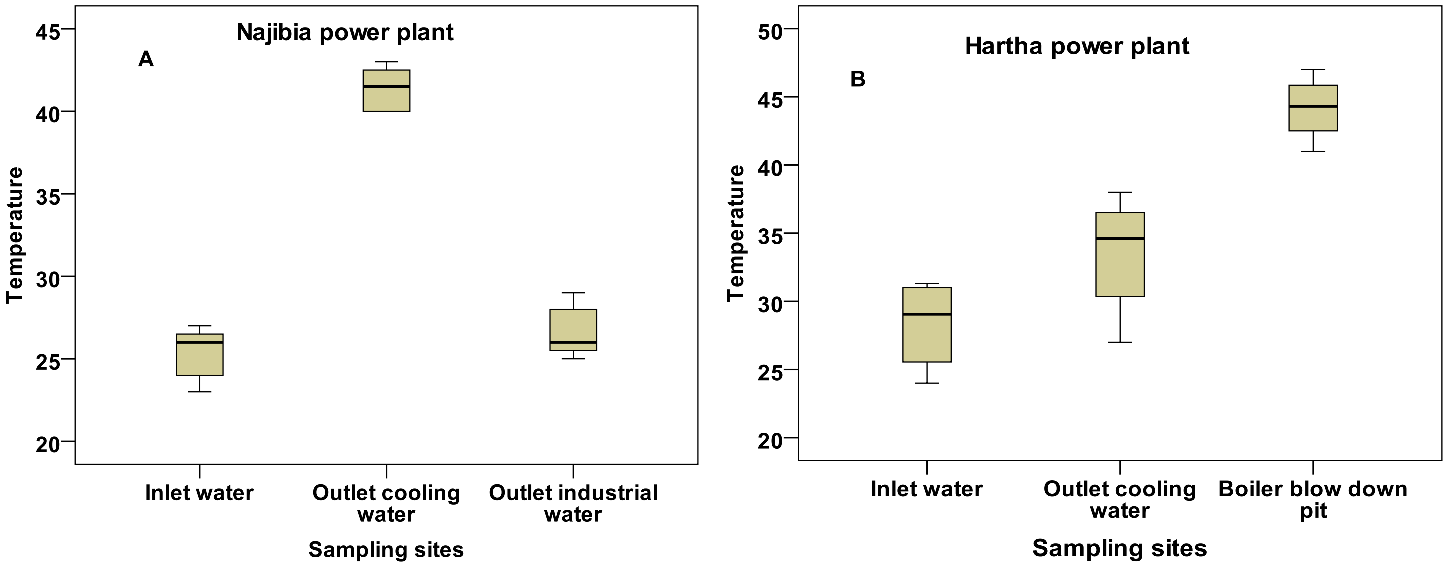

Figure 3: Water temperature results of the power plant sites.

3.1.2. pH:

pH results of both Najibia and Hartha power plants are illustrated below in figure 4. At Najibia power plant the statistical analysis did not show significantly spatial and temporal variations in pH ($p > 0.05$). While at Hartha power plant, there were significantly temporal variations ($p < 0.05$) during the study period where the highest mean was registered at fourth week while the least mean was registered at the first week.

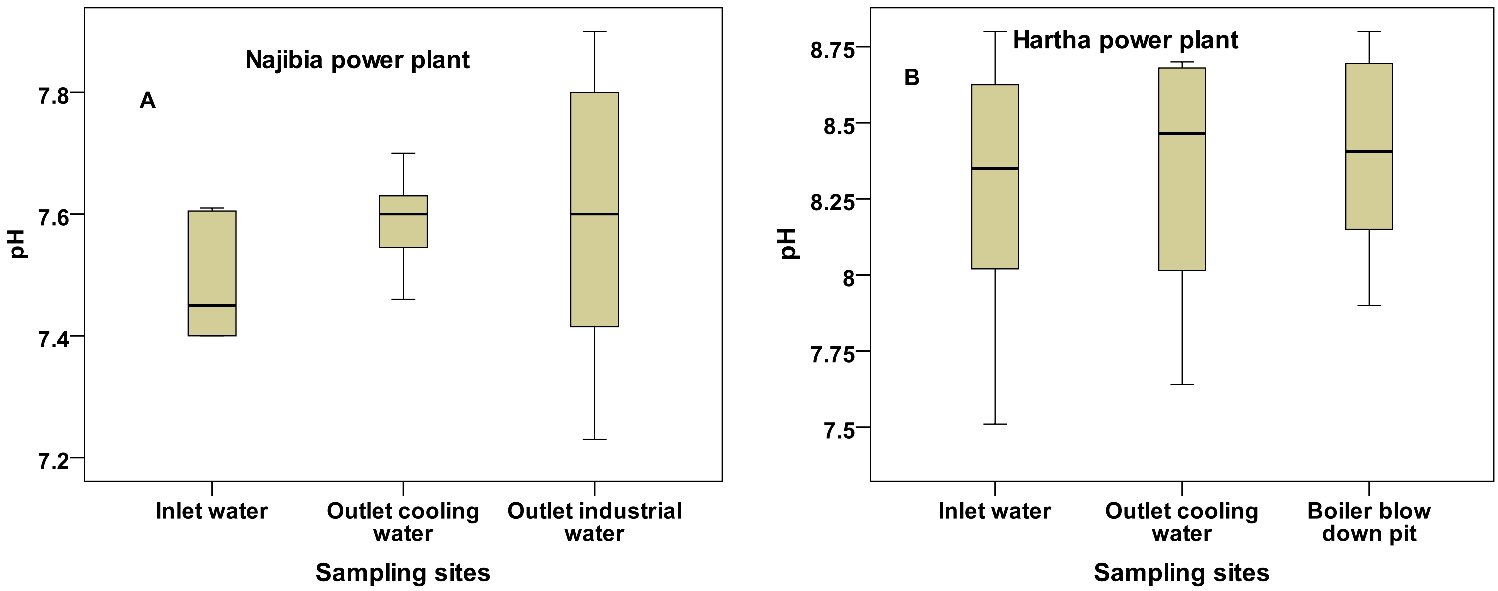

Figure 4: pH results of the power plant sites.

3.1.3. Electrical conductivity:

Electrical conductivity (EC) results measured in µS/cm of both Najibia and Hartha power plants are illustrated below in figure 5.

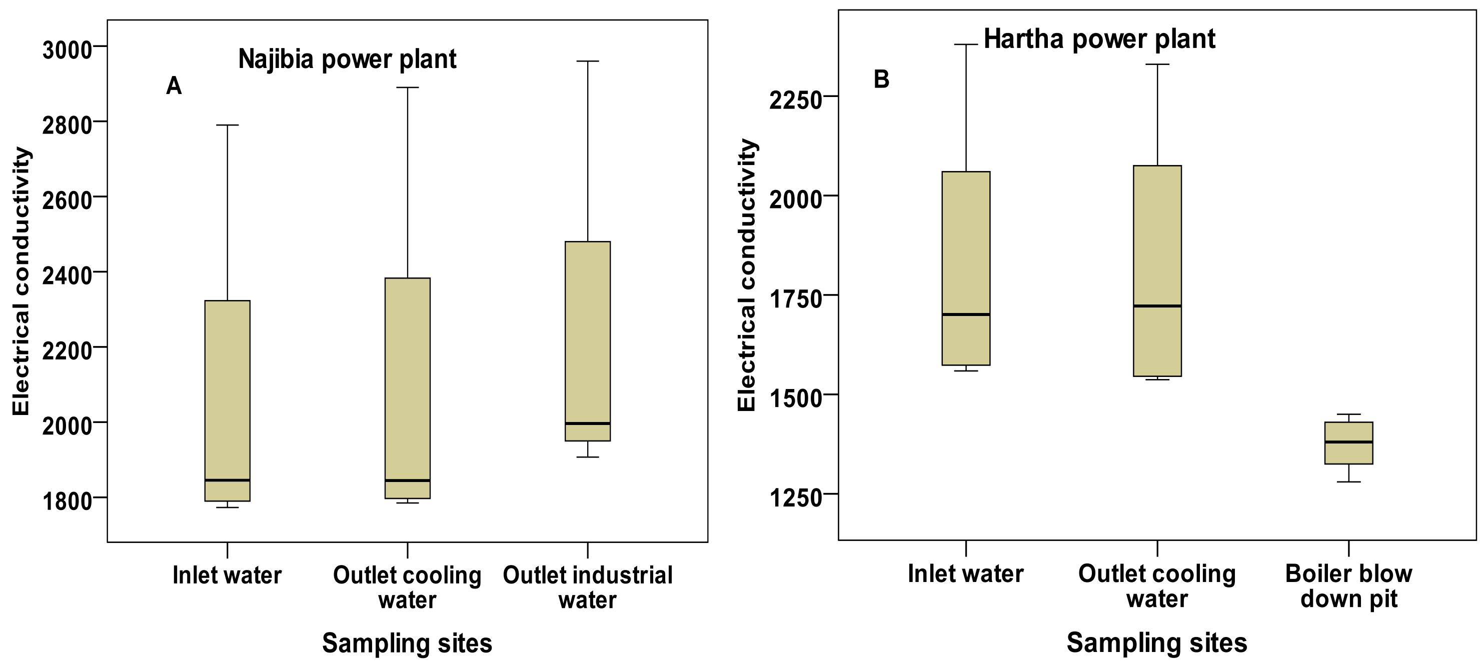

Figure 5: electrical conductivity results of the power plant sites.

At Najibia power plant the statistical analysis showed highly significantly temporal variations ($p < 0.001$) in Electrical conductivity during the study period where the highest average was registered in the first week while the least one was registered in the forth week. While there were high significantly spatial variations ($p < 0.01$) in Electrical conductivity at Hartha power plant sites where the highest mean was registered at site 1 (inlet water) and the least mean registered at site 3 (boiler blow down pit) which significantly differed from the other sites, also, there were temporal variations ($p < 0.05$) where the highest average was registered in the first week whereas the least one was registered in the third week.

3.1.4. Total suspended solids:

Total suspended solids results of both Najibia and Hartha power plants are illustrated below in figure 6.

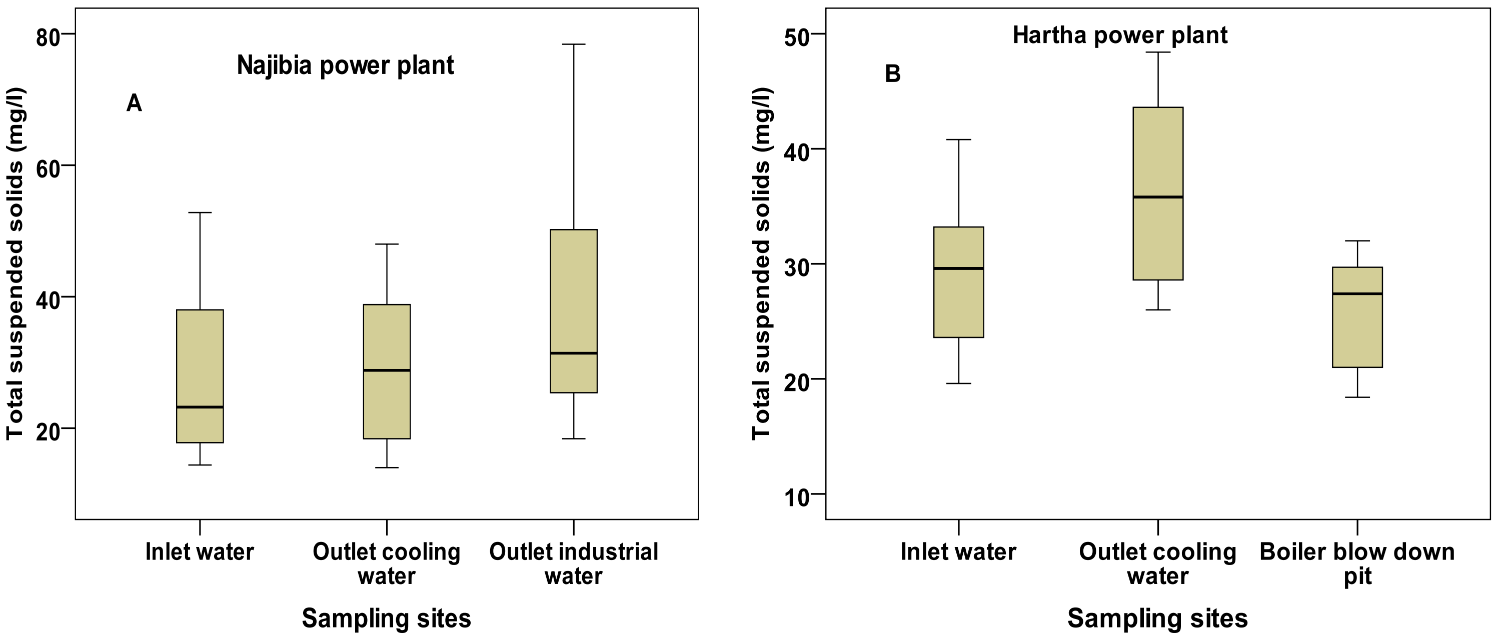

Figure 6: Total suspended solids results of the power plant sites.

At Najibia power plant the statistical analysis showed highly significantly temporal variations ($p < 0.001$) during the study period where the highest mean was registered at the third week which differed from the other weeks while the least one was registered at the second week. While at Hartha power plant the statistical analysis showed significantly spatial variations ($p < 0.05$) among the studied sites where the highest mean was registered at site 2 (outlet cooling water) while the least mean was registered at site 3 (boiler blow down pit) which differed significantly from the other sites.

3.1.5. Chloride ion:

The chloride ion results of both Najibia and Hartha power plants are illustrated below in figure 7. At Najibia power plant the statistical analysis showed highly significantly temporal variations ($p < 0.001$) in chloride ion concentrations during the study period where the highest mean was registered at the first week which differed from the other weeks while the least one registered at the third week. Also, there was significantly temporal variation ($p < 0.05$) in chloride ion concentrations at Hartha power plant where the highest mean was registered at the forth week while the least one was registered at the third week.

3.1.6. Total phosphorus:

At Najibia power plant the statistical analysis as shown in figure 8 A showed high significantly temporal variations ($p < 0.001$) in total phosphorus during the study period where the highest mean was registered at the second week which differed from the other weeks while the least mean was registered at the first week. Also, there was significantly temporal variations ($p < 0.05$) in total phosphorus at Hartha power plant during the study period as shown in figure 8 B where the highest mean was registered at the forth week while the least one was registered at the first week.

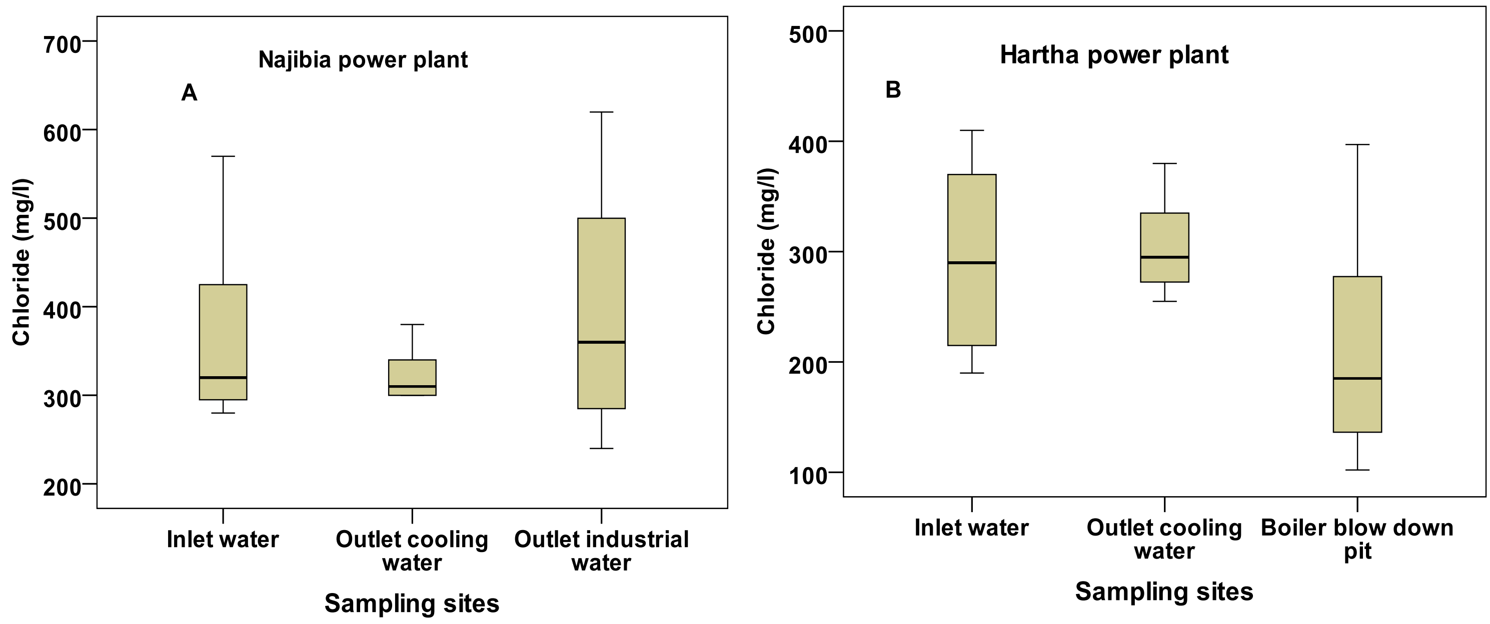

Figure 7: Chloride results of the power plant sites.

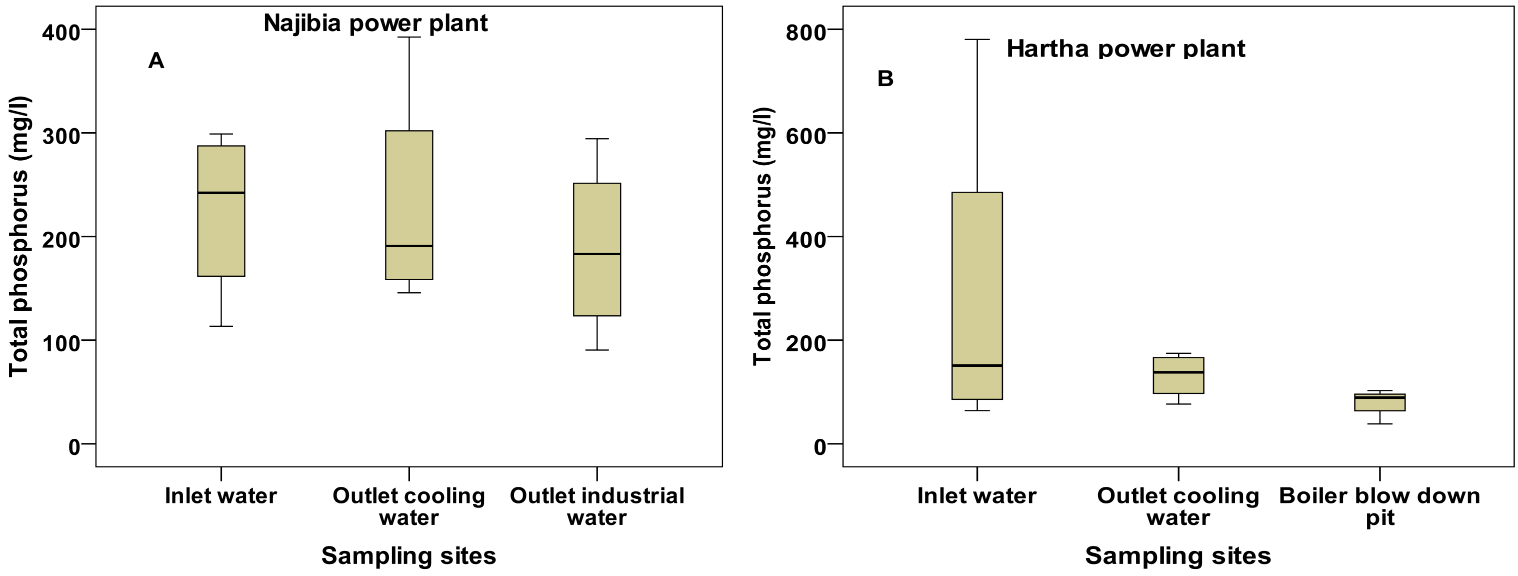

Figure 8: Total phosphorus results of the power plant sites.

3.1.7. Total iron:

At Najibia power plant the results, illustrated in figure 9 A, did not show significantly temporal and spatial variation ($p > 0.05$) while at Hartha power plant, figure 9 B, they showed only high significantly temporal variation ($p < 0.01$) where the highest mean was registered at the second week while the least one was registered at forth week.

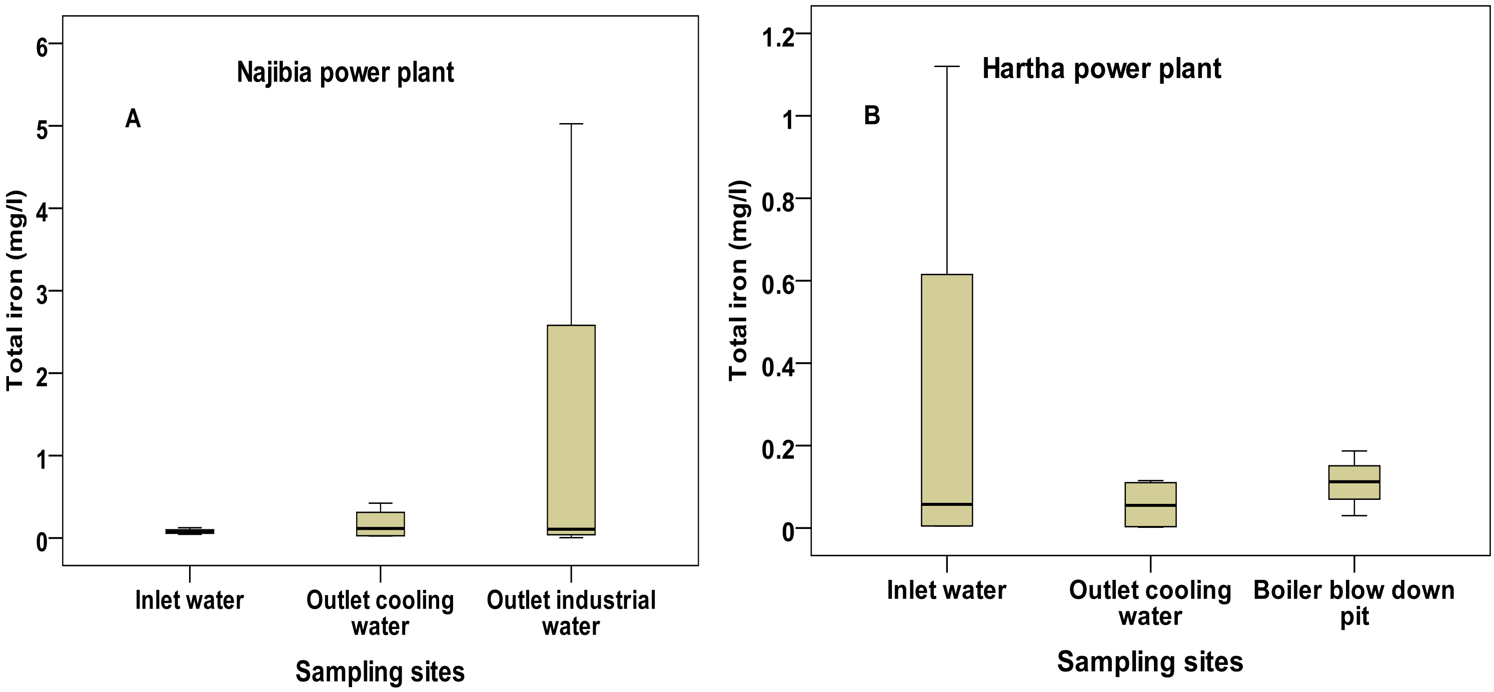

Figure 9: Total iron results of the power plant sites.

4. Discussion:

4.1. Assessment of the environmental impact of power plant effluents:

4.1.1. Water temperature:

Water temperature increased at site 2 (outlet cooling water) comparable with site 1 (inlet water) at Najibia and Hartha power plants, at Najibia power plant it exceeded Iraqi guideline value of waste effluents (< 35 °C) while at Hartha one it was within that guideline [13]. Water temperature at site 3 (Outlet industrial water) was higher than site 1 at Najibia power plant. While site 3 at Hartha power plant (boiler blow down pit) was higher than both site1 and 2 but the industrial wastes drained into boiler pit were cooled then discharged into river therefore, its environmental risk is low comparable with the site 2 (outlet cooling water). The huge amounts of hot water resulting from once – through cooling process lead to decrease level of oxygen and consequently releasing of phosphate from sediments and this case will threaten the life of most aquatic organisms like algae [14, 15, 1, 5, 8] zooplankton [6] and fish [16, 17] by reducing their diversity while permit optimum circumferences for proliferation of tolerant organism like blue-green algae which prefer water temperature ranged from 35-40 ◦C [18]. Other environmental impact on aquatic fauna including entrapment of small organisms which are damaged going through pumps, and entrainment of larger fish in the intake screens [16, 10].

4.1.2. pH:

pH values of the sampling sites at both power plants were found to be neutral to alkaline in nature , pH of site 1 was within the Iraqi guideline value of surface water (6.5-8.5) [13] and the effluents of both site 2 and 3 were within the Iraqi guideline value (6-9.5) of waste effluents [13] which had no effect upon aquatic organisms. These results coincided with both [7] and [9] and can be interpreted as a result of chemicals added to boiler where ammonium hydroxide added for raising pH and preventing corrosion [19, 20].

4.1.3. Electrical conductivity:

The present results showed elevated electrical conductivity at site 2 comparable with site 1 at Najibia power plant due to high temperature which elevated water electrical conductivity as a result of increasing the movement of its dissolved materials [19] while water electrical conductivity of site 2 was lower than that of site 1 at Hartha power plant. For power production in steam power plant, inlet water must be treated in three treatment stages to ensure its suitability for feeding boilers [2]. So, the addition of anti- corrosion and anti- scale chemicals to boiler's feeding water in addition to residual impurities in it would be elevated its electrical conductivity [21, 22] therefore, in order to avoid boiler problems water must be discharge or blow down from the boiler [11]. However, the electrical conductivity result of discharged industrial effluent (site 3) at Najibia power plant was higher than that of river water (site 1) and at Hartha power plant it was lower than that of river water.

4.1.4. Total suspended solids:

The present results of total suspended solids showed that the highest average were registered at site 2 comparable with site 1 because of increasing water flow rate which resulted from pump s' pulled force [14]. In respect to site 3 even with the best pretreatment programs boiler feed water often contains some degree of impurities, such as suspended and dissolved solids these impurities can remain and accumulate inside the boiler as the boiler water operation continues. The present results showed that the highest average of suspended solids was registered at site 3 in Najibia power plant comparable with other sites while at Hartha power plant the least average of suspended solids was registered at site 3 comparable with the other sites. However, the effluents of both site 2 and 3 at both power plants did not exceed Iraqi guideline value (60 mg / l) of waste effluents [13]. The adverse effects of elevated suspended solids is decreasing light penetration through water leading to decrease photosynthesis, accumulation them on aquatic animal’s reproductive places and their food resources, and clogging of fish gills took place when their concentrations reached over than 200 mg / l [23] .

4.1.5. Chloride:

In the present study, the average values of chloride ion for site 1 and 2 at both power plants were less than 1000 mg/l and this indicated that river water was suitable for cooling purpose [19]. While average chloride's ion values of site 3 at both power plants were within the Iraqi guideline value (600 mg/l) of waste effluents [13] where they did not threaten the life of aquatic organisms.

4.1.6. Total Phosphorus:

There are two kinds of water treatment in once-through steam power plant [22, 2] they are:

1- Water treatment processes (flocculation and coagulation, filtration, softening and demineralization) for removal suspended and dissolved solids in order to produce de-ionized water for feeding boiler.

2- Internal boiler water treatments (volatile treatment, alkaline treatment, polyamine treatment and coordinated phosphate treatment) to avoid boiler problems.

So, the prevalence of phosphorus compounds in industrial wastes referred to both kinds of treatment, polyphosphate (calgon) was added before demineralization process for preventing retention of residual iron in order to avoid fouling of ion exchangeable beds where ferric chloride ($FeCl_3$) was added in flocculation and coagulation process as a coagulant material [24] and trisodium phosphate (P_2O_5) was added to control scale forming hardness constituents, (i.e. prevent precipitation of these constituents), by reacting with dissolved solids to form substances that can be removed by blow down [2].

Also, some detergents used for cleaning boilers contained polyphosphate compounds [3] which slowly degraded to orthophosphate in aquatic environment [23]. In aquatic environment concentration of orthophosphorus that support algal bloom is only 0.005 to 0.05 mg/l [24, 25] and the results of all sampling sites at both power plants were high enough to produce eutrophiction phenomenon.

4.1.7. Total iron:

The results of total iron of the studied sites at both power plants did not show spatial variations. The average values of site 1 did not exceed the guideline value (1 mg/l) of U.S.Environmental Protection Agency [26] for freshwater aquatic life. Where as the concentrations of total iron in site 2 and site 3 at both power plants were within the Iraqi guideline value of waste effluents (2 mg/l) [13]. Iron in neutral and alkaline waters will tend to convert from the soluble, ferrous state to insoluble ferric state [7, 20]. It is impossible for this insoluble iron to remain suspended in solution, especially in moving water and the potential toxic effects from this suspended iron generally occur either as damaging to fish gills from its corrosive effects or from smothering of eggs and organisms which lived in the sediment where the iron was deposited [17]. Algae required a small amount of iron for the production of their chlorophyll and most algae grow best when the iron content of water is between 0.2 and 2 mg / l. distinct toxicity is frequently noted when it exceeds 5 mg / l [18, 27].

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دراسة الخصائص الفيزيوكيميائية للمياه المتدفقة من محطات الطاقة الكهربائية في محافظة البصرة.

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الخلاصة : أجريت الدراسة الحالية على محطتي كهرباء النجيبية والهارثة لتقييم الخصائص الفيزيوكيميائية لمتدفقات الطاقة ولبيان التأثير البيئي المحتمل الناتج عنها. وقد جمعت عينات المياه من كلتا محطتي الطاقة لمدة أربع أسابيع خلال صيف عام 2012 حيث أخذت عينات المياه من ثلاثة مواقع (الماء الداخل وماء التبريد الخارج والماء الصناعي الخارج) لتحليل سبعة عناصر (درجة حرارة المياه والأس الهيدروجيني و والتوصيلية الكهربائية والمواد الصلبة العالقة الكلية والكلوريد والفسفور الكلي والحديد الكلي). أزدادت درجة حرارة الماء في موقع رقم 2 (ماء التبريد الخارج) مقارنة مع موقع رقم 1 (الماء الداخل) في محطتي كهرباء النجيبية والهارثة، في محطة كهرباء النجيبية لم تتجاوز درجة حرارة ماء التبريد الخارج قيمة المواصفة العراقية للمجاري المتدفقة ($< 35\ ^{\circ}C$) بينما في محطة كهرباء الهارثة كانت ضمن تلك المواصفة. كانت قيم الأس الهيدروجيني لمواقع جمع العينات في كلتا محطتي الطاقة الكهربائية متعادلة الى قاعدية في طبيعتها إذ كانت قيمة الأس الهيدروجيني في موقع رقم 1 ضمن قيمة المواصفة العراقية للمياه السطحية (6-8.5) وكانت متدفقات موقعي رقم 2 (ماء التبريد الخارج) و3 (الماء الصناعي الخارج) ضمن المواصفة العراقية (6.5-9.5) لمتدفقات المجاري والتي ليس لها تأثير على الأحياء المائية. أرتفعت التوصيلية الكهربائية في موقع رقم 2 في محطة كهرباء النجيبية نتيجة لأرتفاع الحرارة بينما في محطة كهرباء الهارثة كانت التوصيلية الكهربائية لموقع رقم 2 أقل من موقع رقم

1 ، وكانت قيمة التوصيلية الكهربائية لموقع رقم 3 في محطة كهرباء النجيبية أعلى من موقع رقم 1 وفي محطة كهرباء الهارثة كانت أقل من رقم 1 . بلغ أعلى معدل للمواد الصلبة العالقة في موقع رقم 3 في محطة كهرباء النجيبية مقارنة مع المواقع الأخرى بينما في محطة كهرباء الهارثة كان أقل معدل للمواد الصلبة العالقة في موقع رقم 3 مقارنة مع المواقع الأخرى ومهما يكن فأن متدفقات موقعي 2 و3 في كلتا محطتي الطاقة لم تتجاوز قيمة المواصفة العراقية (60 ملغم/لتر) لمتدفقات المجاري. كانت قيمة معدل أيون الكلوريد لموقعي رقم 1 و 2 في كلتا محطتي الطاقة الكهربائية أقل من 1000 ملغم/لتر وهذا يشير الى أن مياه النهر ملائمة لغرض التبريد بينما كانت قيمة معدل أيون الكلوريد في موقع رقم 3 في كلتا محطتي الطاقة ضمن قيمة المواصفة العراقية (600 ملغم/لتر) لمتدفقات المجاري إذ لاتهدد حياة الأحياء المائية. إن تواجد مركبات الفسفور في المجاري الصناعية يعود الى عمليات معالجة المياه وإن نتائج مواقع جمع العينات في كلتا محطتي الطاقة كانت عالية بما فيه الكفاية لأحداث ظاهرة الأثراء الغذائي حيث أنها تحدث في البيئة المائية عندما يكون تركيز الأورثوفسفور من 0.005 الى 0.05 ملغم/لتر فقط . قيمة معدل الحديد الكلي في موقع رقم 1 لم تتجاوز قيمة المواصفة الأمريكية (1 ملغم/لتر) لوكالة حماية البيئة لعام (1986) والخاصة بحماية الحياة المائية في المياه العذبة. بينما كانت تراكيز الحديد الكلي في موقعي رقم 2 و 3 في كلتا محطتي الطاقة ضمن قيمة المواصفة العراقية لمتدفقات المجاري (2 ملغم/لتر).

الكلمات الدالة: محطات الطاقة الكهربائية – المتدفقات – البيئة المائية – قيم المواصفات.