Feasibility Study for Reuse of Zarand Thermal Power Plant Wastewater Passed through Reverse Osmosis Process

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ABSTRACT
Increased urbanization and industrialization have disturbed the balance between water demand and water supply. Thermal power plants are among the largest water consumers and wastewater producers, while wastewater reuse can deal with the both concerns. Effluents of thermal power plants contain various pollutants, so remediation is needed before any other usage. Assessment the efficacy of Reverse Osmosis (RO) system in treatment of Zarand power plant wastewater for reuse was the aim of present work. Physical and chemical parameters including pH, temperature, turbidity, BOD, COD, chromium, sulphate, chloride, nitrate, and phosphate ions were determined in samples collected from three locations of power station: feed water, influent to RO, and effluent. Sampling was done in the first six months of 2012. Data was characterized using descriptive statistics and Excel software. The average performance of RO in the removal percent of turbidity, BOD, COD, chromium, sulphate, chloride, nitrate, and phosphate was 57.5, 14.5, 27.4, 28, 46, 26, 73, and 99% respectively. In spite of less satisfying values of efficiency, mean values of pH, turbidity, BOD, COD, chromium, chloride, nitrate, and phosphate measured in effluent passing through RO were 7.5, 0.14 NTU, 1.8, 2.83, 0.018, 320, 1.6, and 0.001 mg/l respectively, all in compliance with discharging or irrigation standards, while 704 mg/l of sulphate ions detected in effluent, were much higher than acceptable limits.

Key words: Reverse Osmosis, Thermal Power Plant, Wastewater Reuse

INTRODUCTION
Increasing urbanization in developing countries can be promoted the living standards of residents, and can intensify the utilization of fresh water resources for domestic, commercial, and industrial usages [1]. These dramatic changes have resulted in drastic stress on water resources [2] which is expected to be aggravated within the next decades [3]. Two issues are problematic in this regard; one of them comes from the challenge of imbalance between water demand and water supply, while the other is handling the huge volume of remained wastewater [4]. Consultative Group on International Agricultural Research (CGIAR) has predicted that 2.7 billion people will be living in water-scarce habitats in more than 80 countries by the year 2025 [5, 6]. Unavailability of sufficient safe water in many areas of earth, has led to adopting a variety of strategies to deal with the shortage. Wastewater reuse is one of the principal strategies [7] which can reduce the overall water consumption and the global volume of industrial plants effluent [8]. In the late twentieth century, the idea of reuse gained strength and it was expected that treated municipal and industrial wastewaters could produce recycled water in such a quality to be utilizable for different purposes such as agriculture, aquaculture, artificial recharge of ground water resources, and industry [9]. Raw or diluted wastewater or water resources polluted with wastewater are in use by small-scale farmers for agricultural land irrigation in urban and peri-urban areas of many developing countries [4]. In recent years, Iran's water resources on surface or in the ground have been threatened by wastewater discharges, especially from industrial activities [10]. But this is not the only issue, non-uniform distribution of water resources and periodic droughts also have raised concerns about water access [11]. Therefore, at the national level, developing strategic plans consists of solutions like reuse of treated wastewater to conserve water resources and to control pollution has been taken into consideration [10]. Moreover, wastewater reclamation for reuse has been known as an inseparable component of sustainable water resources [12]. Greek researchers developed a strategic plan for reuse of treated municipal wastewater for agricultural irrigation on the Island of Crete. The results of this survey

indicated that investigated wastewater treatment plants were not successful to meet the criteria for unrestricted irrigation of the yields [1]. Yazdani *et al.* examined the quality of Parkandabad wastewater treatment plant effluent for its probable agricultural usages. They reported a poor quality status in terms of environmental standards for agricultural application of refined wastewater [13]. Indian researchers assessed the contamination of water resources close to a thermal power plant in India. Results indicated that the well, stream and pond water within the study area were contaminated with heavy metals at levels higher than the maximum acceptable limits of drinking water guidelines [14]. Direct use of industrial effluent before applying appropriate treatments methods may cause to adverse consequences on health [7]. Industrial discharges must be monitored for physical, chemical, or biological substances, nutrients and pathogens dependent on the corresponding processes before any form of further application [15]. To assure the protection of public and environmental health, the quality of treated wastewater should be proportional to the environmental standards [16]. So far, for industrial effluent treatment, with respect to the qualitative and quantitative characteristics of wastewater in each facility, various approaches have been proposed and tried [11]. Literature has addressed RO method as one of the optimal approaches for efficient treatment of industrial waste streams [16]. In addition to wastewater treatment RO membranes have found uses for producing ultrapure water, brackish water desalination, water softening, food processing and many others [17]. In RO purification system, a semi-permeable membrane acts as a barrier vs. pollutants which simultaneously separate and concentrate both organic and inorganic substances. Small pore size of RO membranes also provides the chance for molecules and ions separation [16]. It is a pressure driven process in which applying a pressure difference across the membrane enforces the water of a stream to permeate through the membrane [18]. Simplicity of its modular design [19], convenient operation, equipment compactness, working environment safety [20], and automatic control of process [21] are some stunning benefits of RO technology. The treatment feasibility of wastewater in Tabriz Petrochemical Complex was evaluated using RO pilot plant. The results showed extensive decrease of effluent quality indicators like COD, BOD, TDS, and solids using RO membranes [22]. Reuse of industrial park wastewater in southern Sweden treated by RO plant resulted in reduced use of fresh water and lower discharge charges [15]. In France RO treatment of the dairy industry wastewater was carried out and 90–95% water recovery was achieved [8]. RO process was implemented by Fababuj-Ruger *et al.* [23] as the final stage for tannery wastewater treatment and it was introduced as the best possible way of wastewater reuse in the tannery industry.

Infrastructural industry of electricity generation has been recognized as an index of development in every country. Power plants like other industries are a source of wastewater generation. Restore and reuse of power plant wastewater, taking into account that powerhouse is among the major water consumers, and with respect to the critical importance of water, has been expressed as one of the main objectives of environmental protection [24]. So far, few studies have been done on the reuse of power plants wastewater. Dehghan *et al.* [25] investigated the performance of Yazd Combined Cycle Power Plant's wastewater treatment system utilizing an extended aeration activated sludge process for reuse of refining wastewater in agricultural sector. Qualitative parameters including pH, BOD, COD, and TSS of treated wastewater were in compliance with standards of Iran Department of Environment (IDE), but regarding chemical characteristics, the effluent was found to be proper for irrigating plants resistant to salinity. In the study performed to find the potential of industrial wastewater reuse in Jordan's Al Hussein thermal power station, RO was introduced as a proper way for wastewater recirculation in the plant to be used as process water [26].

Given the importance of wastewater reuse at power plants which are known as one of the largest water consumers in industrial scale, present work was conducted to evaluate the performance of RO system for wastewater treatment in Zarand thermal power plant with emphasis on effluent acceptability for agricultural uses or land disposal. Zarand station is one of the oldest power plants in Iran which was founded with the aim of using the coal sources of mines in the area in addition to the supplying the electrical energy required for the south east of the country. Given the shortage of water resources in this area and by considering the high costs of water extraction for supplying the water demand of the station, the importance of water recycling and water reuse in such circumstances gets double. So, researchers of the current study decided to investigate the feasibility of such actions through this work.

MATERIALS AND METHODS

Location and effluent

Zarand thermal power plant is located 75 Km away from the capital of province of Kerman, Iran. This is the first coal-fired power plant in Iran adjacent to coal washing plant of Zarand and two rich coal mines which have been put into operation in 1973.

Production capacity of Zarand thermal power station is 220 MW. The site area of this station is 19.5 hectares. Three deep wells around the station supply the water requirement for various activities in the power station at a rate of 200m^3/h. The Longitude and Latitude coordinates for the water wells are as follow: x_1:56.612639396 and y_1: 30.8071011239, x2:56.61272522750 and y2: 30.8129248015, and x_3: 56.6059660607 and y_3: 30.811837496. The raw water was collected in storage tanks and then was consumed through two separate paths; internal and external cycles. In the internal cycle, produced distilled water was driven into the turbine for the production of steam, and then as a result of condensation, the water was returned back into the turbine. In the external cycle, the raw water was driven into the cooling towers and after adjusting its pH, controlling its saturation index, and disinfection, output cold water was driven toward power plant condensers. Finally, after cooling various parts, it was returned back to the cooling towers. Wastewater from Zarand powerhouse includes discharge of water purifiers, wastewater from cooling tower, and wastewater from repair, turbine, and depot units which is likely to contain oil, wastewater from wash of exterior surfaces, wastewater from chemical cleaning of boiler tubes, domestic waste water and surface runoff. Cooling tower wastewater besides the thermal pollution, contains chemicals and chlorine. Phosphates or other chemicals which are used for preventing scale formation or corrosion can be found in wastewater stream. Heavy metals like zinc and chromium are the major ingredients of waste water from washing of exterior surfaces such as boiler tubes, economizer and furnace. In facilities RO system is in operation using membrane FILMTEC BW30-400 at flow rate of 80 m^3/m^2 h.

Sampling and analysis

Sampling points were selected at three locations: water entry to the power station, in entry of RO system, in RO exit. Water and wastewater sampling from these stations were accomplished according to the Standard Methods for the Examination of Water and Wastewater [27] in a 6-month period (January–June 2012). In this regard, one sample in a minimum of 10 Litre for chemical/physical analyses was collected in a specified date of every month. Selected samples were analyzed for Sulfate, Nitrate, Chloride, Phosphate, Chemical Oxygen Demand (COD), Biochemical Oxygen Demand (BOD), pH, turbidity, temperature, and heavy metals zinc and chromium. All lab analyses were performed by the procedures outlined in standard methods for the examination of water and wastewater in the accredited laboratories of IDE and rural water and Wastewater Company. Spectrophotometer Hach DR-5000 was used for measurement of sulphate, nitrate, and phosphate. Sulphate was measured at a wavelength of 450nm using turbidity test with a reagent kit containing Barium Chloride and Citric Acid. NitraVer 5 reagents were used to determine the concentration of nitrate in the wavelength of 500nm. Program number 490 on DR-5000 device was applied for the measurement of phosphate ions concentration in the samples. Potentiometer titration was used to determine the concentration of chloride. The amount of BOD in the samples was determined using BOD meter oxy-directed Lovibond®, while COD values were measured by COD analyzer (Aqualytic Germany). The Hach 2100 Q portable turbidimeter was used for determining the amount of turbidity in samples on the basis of instruction 2130 of the Standard Methods for the Examination of Water and Wastewater. The Hach HQ440d was used for testing the pH of samples. Varian aa240fs atomic absorption spectrophotometer was applied for detecting the metal concentrations. Temperature was measured using a mercury thermometer according to the instruction 2550 of the mentioned reference book. Data was analyzed using descriptive statistic and Excel software.

RESULTS

In total, by present investigation over a 6-month period of sampling, 18 samples were collected and each sample was analyzed regarding 11 physical and chemical parameters including pH, temperature, BOD, COD, zinc, chromium, sulphate, nitrate, chloride, phosphate, and turbidity. So, the number of experiments conducted by this work was 198 tests. The experimental results of the current study are presented using table and figures, while some of them are just provided in the text. The physio-chemical characterization of water and wastewater samples taken from three sampling points is given in table 1.

As table 1 shows, pH of the raw water samples was varied between 7.9 and 8.3, while the range of this parameter at the outlet samples was in fluctuations between 7.1 and 7.7. The average values of pH in all sampling points are provided by Fig. 1. The standard values regarding the permitted range of pH in the effluent are presented in the caption of Fig. 1. Fig. 1 also represents the average concentration of nitrate ion in the raw, polluted and treated water samples of the power station which indicates a removal efficiency of 73% for this parameter. With respect to Table 1, 10.45-13.1 mg/l of nitrate ions were measured in the feed water supplied by wells, while values of this parameter were in a range between 0.8 and 2.4 mg/l in the samples treated through RO. Standard limits regarding the nitrate concentration in the effluent have been explained by caption of Fig.1.

Table1. Measured quality parameters for a six-month period at three sampling locations

Source of sampling	Physicochemical Parameters								
January	**pH**	**Tur**	**BOD_5**	**COD**	**Cl^-**	**NO_3^-**	**PO_4^{3-}**	**SO_4^{2-}**	**Cr^{3+}**
Input water (S1)	8.1	0.66	10.5	24	418	12.6	0.01	1340	0.05
Entry of RO (S2)	7.9	0.25	1.6	4	438	6	0	1290	0.02
RO exit (S3)	7.6	0.15	1.5	2.5	318	1.8	0	687	0.02
February									
Input water (S1)	8	0.74	10	23	421	12.7	0.04	1340	0.05
Entry of RO (S2)	8	0.25	1.7	3.9	442	6.2	0	1291	0.03
RO exit (S3)	7.5	0.14	1.6	2.5	323	1.6	0	684.5	0.02
March									
Input water (S1)	7.9	0.6	10	24	415	13.1	0.01	1344	0.02
Entry of RO (S2)	7.4	0.32	1.9	4.3	432	7.2	0.02	1300	0.02
RO exit (S3)	7.1	0.11	1.7	2.6	324	2.1	0	686.5	0.01
April									
Input water (S1)	8	0.56	13	27	432	11.5	0.12	1352	0.03
Entry of RO (S2)	7.9	0.32	2	4.2	441	5	0.3	1310	0.03
RO exit (S3)	7.5	0.1	1.8	3.1	320	2.4	0.01	721.7	0.02
May									
Input water (S1)	8.1	0.7	12.8	28	423	10.45	0.06	1386	0.02
Entry of RO (S2)	8	0.4	2.2	3.4	430	4.4	0	1353	0.01
RO exit (S3)	7.6	0.15	2.1	3	322	0.8	0	720.3	0.01
June									
Input water (S1)	8.3	0.62	15	31	423	12.3	0.86	1346	0.05
Entry of RO (S2)	7.9	0.44	3	3.6	426	7	0.3	1339	0.04
RO exit (S3)	7.7	0.2	2.1	3.3	315	0.9	0	724	0.03

Tur: turbidity (NTU), Columns: 4 to10 (mg/l) in which BOD: biochemical oxygen demand, COD: chemical oxygen demand, Cl: Chloride, NO_3: Nitrate, PO_4^{3-}: Phosphate, SO_4^{2-}: sulphate, and Cr^{3+}: Chromium.

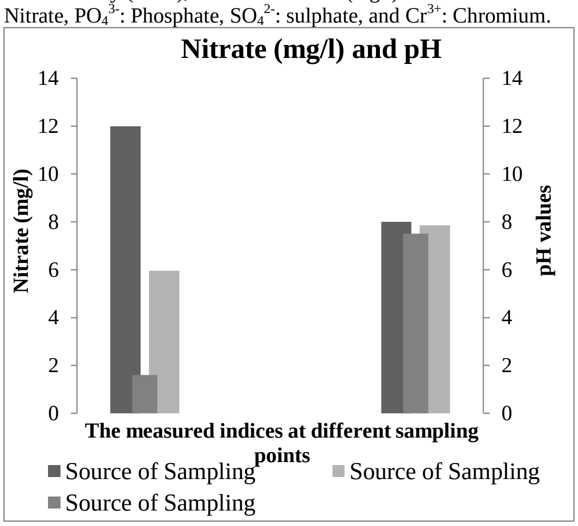

Fig. 1: Six months' mean value of pH and Nitrate (mg/l) at different sampling points.

The standard value of pH regulated by IDE for discharging the effluent to surface water supplies: 6.5-8.5, to wells: 5-9, and for land irrigation: 6-8.5, and EPA standard for land irrigation: 6.5-8.5. The standard value regarding nitrate concentration in the effluent regulated by IDE for discharging the effluent to surface water supplies: 50 mg/l, to wells: 10 mg/l and EPA standard for land irrigation: 30 mg/l.

Turbidity levels in samples taken from all sampling points are shown in table 1. Based on the values associated with this parameter, the most turbid sample of the well water had a turbidity of 0.74 NTU, while the most amount of turbidity in the samples taken after RO was 0.2 NTU. Data presented on the columns related to this parameter in Fig. 2 shows that the turbidity in the output of RO was fallen averagely 57.5% relative to the input of RO. The caption of Fig. 2 provides some information in relation to the limitations considered for the level of turbidity in the effluent by local and foreign regulatory agencies.

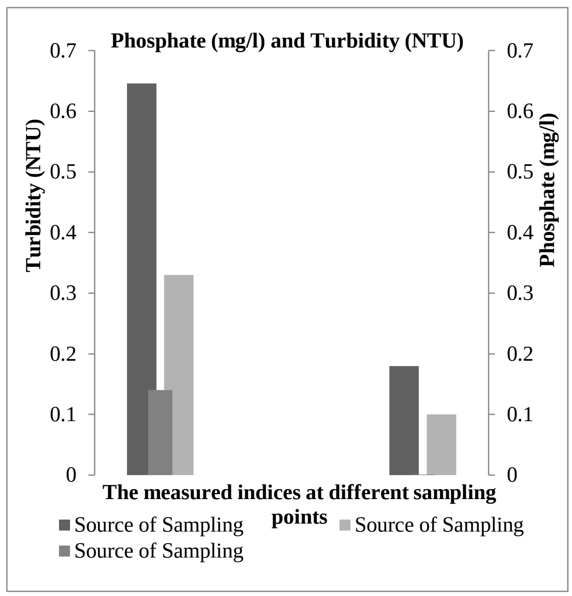

Fig. 2: Six months' mean value of turbidity (NTU) and Phosphate (mg/l) at different sampling points.

The standard value of turbidity regulated by IDE for discharging the effluent to the surface water supplies and also for land irrigation: 50 NTU and EPA standard for land irrigation: 2 NTU. The standard

value of phosphate regulated by IDE for discharging the effluent to the surface water supplies and to wells: 6 mg/l and EPA standard for land irrigation: 10 mg/l.
Table 1 indicates that the maximum concentration of phosphate in the raw water samples was seen in the last month of sampling equal to 0.86 mg/l, while the minimum quantity of this ion in the feed water was 0.01 mg/l. Table 1 also exhibits a slight increase in the phosphate concentration of feed water in passing from various parts of power station in March and April which was reduced after coming to RO system. Fig. 2 has addressed the changes occurred in the concentration of phosphate before and after confronting to RO system. Accordingly, the capability of RO treatment system in reducing this parameter was 99%.
As shown in table 1 the values of parameters BOD and COD in the feed water were much higher than the inlet of RO. The maximum concentration of BOD in the raw water was 15 mg/l and the least amount of that in the water produced by RO was found at 1.5 mg/l. As illustrated in table 1, 23-31 mg/l of COD concentration was detected in the feed water, which was reduced to some values between 3.4 and 4.3 mg/l before coming to the RO. The data for the RO treatment efficacy with respect to BOD and COD levels can be seen in Fig. 3. Accordingly, the average concentration of BOD at the inlet of RO was 2.1 mg/l which was reduced to 1.8 mg/l at the product water of RO. According to Fig. 3, the mean amount of COD in the influent to RO system was found at a concentration of 3.9 mg/l which was reduced to 2.83 mg/l in the effluent.

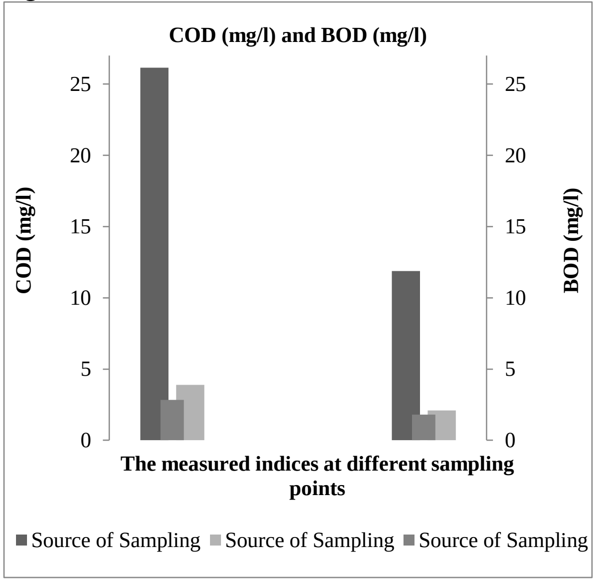

Fig. 3: Six months' mean value of BOD (mg/l) and COD (mg/l) at different sampling points.

The standard values of (BOD and COD) regulated by IDE for discharging the effluent to the surface water supplies and to wells: (30 and 60), for land irrigation: (100 and 200), and EPA standard for land irrigation: (30 and 120) respectively.
By looking at Fig.4, it can be found that the average concentration of sulphate in the water product of RO was 704 mg/l which was higher than the maximum permitted value for discharging the effluent contaminated by this ion to receiving environments or using the outflow stream for irrigation. So, the effluent did not meet the reuse standards in terms of sulphate ions. The degree of RO success in reducing the concentration of sulphate was 46.4%, while its efficacy was even lower in the case of chloride removal as it was shown equal to 26.4%. However, the average level of chloride in the RO output was 320 mg/l, which was less than the maximum allowable concentration of chloride in the outflow (600 mg/l).

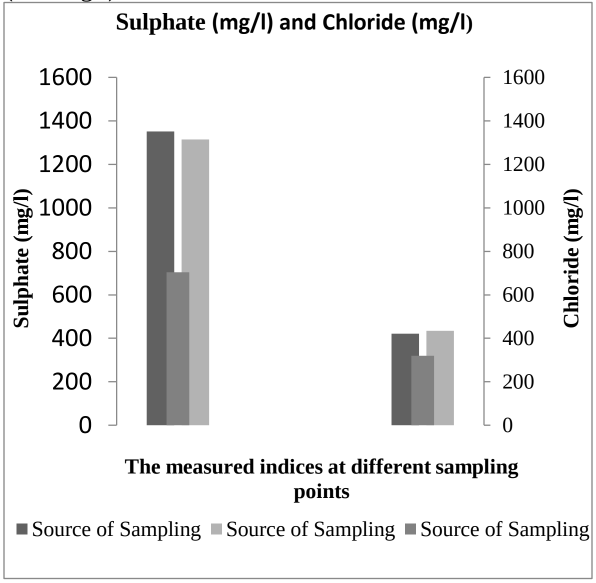

Fig. 4: Six months' mean value of sulphate and chloride (mg/l) at different sampling points.

The standard value of sulphate regulated by IDE for discharging the effluent to the surface water supplies and to wells: 400 mg/l, and for land irrigation: 500 mg/l. The standard value of chloride regulated by IDE for discharging the effluent to the surface water supplies, to wells, and for land irrigation: 600 mg/l.
The experimental results regarding the levels of chloride ions presented by table 1 show that amount of this parameter was increased in the water in passing from different sections of a power station.
In the current study, also some analyzes were conducted to determine the possible concentration of two heavy metals; zinc and chromium. The concentration of zinc was detected at zero level in all samples taken from all of the sampling points; hence this parameter was not inserted in the table 1. According to table 1, the maximum concentration of

chromium in the raw water samples and in the samples taken from the inlet water to the RO system were 0.05 and 0.04 mg/l, respectively. The concentration of this metal in the effluent ultimately was reached to 0.01 mg/l. The efficiency of the treatment system for the removal of Cr^{3+} was 33.33%. Another parameter which was not neglected was the temperature of outflow samples. In this regard, the outflow wastewater temperature was measured at the time of sampling in each month. The minimum and maximum recorded values of temperature in the effluent were 21 and 26 ℃.

DISCUSSION

Water requirement of Iran thermal power plants is mostly supplied using sea water, rivers, deep well, and piped water. Three deep wells feed the thermal power station of Zarand. Water demand is also provided through deep wells for some of the other power stations in Iran such as Besat, Montazer Ghaem, Shahid Rajaee, Tabriz, Mashhad, and Touss plants. Niroo research institute has released some reports on the quality of raw water entering to these stations. The average chloride concentration in the water entering to the Zarand power station (422 mg/l) is higher than all the mentioned plants with the exception of Tabriz power plant (560 mg/l). Besat, Shahid Rajaee, Mashhad, and Touss power plants receive water having more concentrations of nitrate in comparison to Zarand station (12 mg/l NO_3). 1351 mg/l of sulphate ions were detected in entering water to study station which is far more than the value of this parameter ranged from 40-202 mg/l in the other stations [28]. Results of table 1 indicate that the concentration of phosphate (in some cases) and chloride (in all cases) in the water passing units of the plant had been increased. This can be attributed to substances such as hydrazine, phosphate, hydrochloric acid, sodium hypochlorite and calcium hypochlorite which have been used for washing different units of plant. In addition, factors such as residence time of water in the system, duration of the use of pipes, connections of treatment system and indoor plumbing are known as factors involved in the release and leakage of chemical compounds from pipes into the water [29]. Reduced sulphate concentration in the output of RO reported through this study is in disagreement with the effluent data from Besat, Montazer Ghaem, Shahid Rajaee, Tabriz, and Mashhad power plants where the amount of sulphate ions seen in the effluent was much higher than raw water [28]. However, in this study, sulfate concentration in output had not reached even close to the standard limits. Another issue regarding sulphate concentration was more amounts of this parameter in the effluent incoming to the RO in the second trimester of sampling in comparison to the first trimester. It has been known that a proportion of in putting water were consumed in the cycle of cooling towers (called as external cycle). A large amount of water of this cycle was discharged daily to the wastewater stream. According to the study conducted by Khosravan and Bakhtiari [30] the amount of sulphate ions in the water of this cycle was more than its amounts in the water which has flowed in the internal cycle. Given that the peak load of power plants sometimes occurs in warm seasons, the volume of water required for cooling processes as a result rises. So, more proportion of water would be consumed in the external cycle which leads to the increase of wastewater generation. This effluent had more amounts of sulphate ions. Accordingly, more amounts of sulphate ions were entered to the wastewater flow and were detected at the inlet point of RO system in the second trimester of sampling as table 1 shows. As a result, higher input of sulphate ions to the RO system in the second season of sampling was led to the reduction of the process efficiency. Based on the effluent discharge standards set by IDE, the maximum permissible limit of trivalent chromium in effluent for being discharged to surface waters, to well, and to be used for land irrigation is 2 mg/l. while, EPA has determined more stringent standard for agricultural land irrigation (1 mg/l of chromium in effluent). A simple look to table 1 specifies the amount of chromium in all discharging samples much less than both mentioned limits, although no difference was seen for Cr concentration in the influent and effluent of RO system in January and May. The permitted pH ranges of the effluent for being discharged into various receiving environments are cited attached to Fig.1. Regarding mean value of pH in Fig.1 not only there is no restriction for disposal of effluent to surface water supplies and wells but it can be used for land irrigation. The observed reduction in the pH of the outlet samples in comparison to the feed water samples can be attributed to the presence of gases like CO_2 which was not removed in passing through RO and consequently was converted into carbonic acid [31]. Amount of turbidity in the outlet of the treatment system was detected at 0.14 NTU, while the discharging standard was defined as 50 NTU. The mean amount of turbidity in the water supplied from deep wells entering to Yazd combined cycle power plant was 0.64 NTU just as the observed turbidity at 0.646 NTU in the raw water feeding Zarand station [24]. As many aquatic organisms, have shown biological sensitivity to water temperature, increase of water temperature by power plant discharges may have multiple impacts on aquatic ecosystems [32]. High dependence of some aquatic organisms on specific thermal conditions in aquatic bodies can cause stress or even death if the temperature of the water goes above or below optimal thermal regimes [33]. Madden *et al.* investigated the effect of power plant cooling systems discharges on aquatic life. More than half of all studied power stations had showed maximum temperature at discharges which had exceeded 32 ℃. As a result, water temperatures had increased enough to potentially impact aquatic life [34]. Hence, there is a vital importance regarding temperature measuring in the power plant discharges. In a study conducted in educational hospitals of Yazd city, the performance of RO system in treatment of water required for hemodialysis was assessed. Some physicochemical parameters were measured in the samples of input and output of RO. The pH of the samples taken at the output of RO was between 7.30 and 7.73 which were very close to the pH levels reported by the current study as 7.1-7.7. The best efficiency of RO for the removal of chloride and sulphate was reported equal to 44.23% and 92% respectively, while the removal efficiency of these ions in the samples of Zarand station was 26% and 46% respectively. Although, it should be considered that the initial concentrations of the two mentioned parameters measured in the samples taken out from the inlet water to the RO system, were not comparable between Zarand station and Yazd hospitals [35]. Mishra *et al.* [36] studied the effectiveness of RO in the treatment of bore well water samples. The system applied by them caused to the reduction of total dissolved solids from 590.5 mg/l to 50 mg/l. In the study carried out by Dehghani *et al.* [37] the level of turbidity in the wells water in putting to the RO was 0.17 NTU and it was reached to 0.1 NTU after passing the RO, while in present work the level of this parameter in the samples taken from input and output of RO was 0.33 NTU and 0.14 NTU, respectively. Jacobson *et al.* [38] observed no phosphate removal in the samples of surface water passed through RO. Hasar *et al.* [39] used RO as a tertiary treatment and achieved 99.2% removal for COD of landfill leachate samples. Schoeman and Steyn [40] studied the removal of nitrate from borehole water samples using RO in the rural area in South Africa. The results were indicated on the reduction of nitrate-nitrogen concentration from 42.5 mg/l in the feed water to 0.9 mg/l in the RO product water. Treatment system used in Zarand thermal power plant showed relatively good efficiency in the removal of most of the studied parameters, but it should be noted that the effluent exited from RO system having such a quality as measured through this assay was not discharged directly to receiving environments and this was mixed with untreated wastewater which had not entered into the RO system. So different values of measured parameters are likely in the combined effluent. If there was the possibility for researchers to take more samples from different locations like full drain, then it could help to clarify the matter.

CONCLUSION

Present study is concerned with the performance evaluation of RO method for treating power plant wastewater and the compliance of effluent at the discharge or irrigation standards for wastewater reuse. The current results suggest that the RO effluent is complying with the standards for being discharged to aquatic environments based on pH, temperature, turbidity, nitrate, chloride, phosphate, BOD, COD, zinc and chromium. Although, same circumstances of parameters can be seen in terms of agricultural land irrigation, but this is worth noting that there are many physicochemical parameters which determine the quality of irrigation water and the amounts reported by this study should not be the criterion for decision making.

ETHICAL ISSUES

This paper comes from an original research without any plagiarism, data fabrication and/or falsification, double publication and/or submission, and redundancy.

CONFLICT OF INTEREST

No competing interest has been reported by the authors.

AUTHORS'CONTRIBUTIONS

Ataei led the project in all the stages, while rest of the authors have performed sampling, experiments, data gathering, analyzing, literature searches and writing.

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