Monitoring of 2,4-dichlorophenoxyacetic acid concentration in Karun River and effluents of water treatment plants

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ABSTRACT
This study aimed to determine the concentrations of 2,4-dichlorophenoxyacetic acid (2,4-D) using salting-out assisted liquid–liquid extraction (SALLE) in influent and effluent of Ahvaz water treatment plants during 2018–2019. All measured concentrations were less than the maximum allowable concentrations recommended by the National Standards Organization of Iran (1053) and WHO guidelines. The results showed that the Ahvaz treatment plant decreased the concentration of 2,4-D by 69.2%. Therefore, it is necessary to measure the persistent organic pollutants such as pesticides in different seasons, especially in autumn, winter, and spring that the chemical fertilizers and pesticides are commonly used.

Introduction
Chemical pesticides are a major group of environmental pollutants that are found in aquatic and soil environments. Excessive use of pesticides in agricultural production causes a phenomenon called pesticide residues, which poses a risk factor to the environment and human health (Pirsaheb et al. 2012, Bhat et al. 2015). Phenoxyacetic acid compounds are among the most important pesticides that are widely used in agriculture. 2,4-Dichlorophenoxyacetic acid (2,4-D) is one of the most important herbicides of this group that is commonly used in agriculture (Smith et al. 2000).

Khuzestan Province, as one of the main agricultural and economic hubs of Iran, is the sixth province in Iran that uses pesticides (Golshan et al. 2018). 2,4-D has been classified as a hazardous substance (class III) by the World Health Organization (WHO), and the maximum allowable concentration of this pesticide in drinking water is 100 μg/L. However, WHO later changed that to a second class pollutant (class II) and established 70 μg/L as the maximum allowable concentration for this pesticide in drinking water (Pohanish 2014). The US Environmental Protection Agency (USEPA) has set a permissible limit of 0.1 mg/L for 2,4-D in water (Kundu et al. 2005). The breakdown of 2,4-D by microorganisms is very difficult, especially at high concentrations. Long-term exposure to 2,4-D can cause inflammation of the eye and skin, as well as affect the central nervous system. It has been reported that long-term exposure to this herbicide is associated with liver and kidney cancers (Han et al. 2010, Bian et al. 2013). Also, besides, its adverse effects on the endocrine system have been well known (Romero-Natale et al. 2020). On the other hand, 2,4-D is wieldy used nowadays for various purposes due to its low cost and good performance (Ai et al. 2011, Liu et al. 2014). The USEPA has identified that as the third most widely used herbicide worldwide (Rong et al. 2016). The presence of high concentrations of this herbicide has been severally reported in agricultural drainage and groundwater (Ren et al. 2012, Hong et al. 2015). Therefore, due to its widespread application and high toxicity, it must be removed before being discharged into the environment (Naseri et al. 2009, Del Angel-Sanchez et al. 2013, Liu et al. 2013). Since the presence of such pesticides in water can cause damage to...
aquatic environments, aquatic life, and human health, several management measures are required to control contaminated sources, such as minimizing the use of pesticides, training of farmers about the use of pesticides, preventing the discharge of agricultural drainage into the river, and applying integrated pest management (Pinto et al. 2010, Padron et al. 2014, Gezahegn et al. 2019). The first step in controlling and managing pesticide residues in water resources is determining their concentrations with a highly sensitive and accurate method to compare the residual concentrations with the recommended standards (Pinto et al. 2010, Padron et al. 2014, Gezahegn et al. 2019). Several procedures were reported for the pre-concentration of pesticides from water matrices, including solid-phase extraction (SPE), solid-phase microextraction (SPME) (Chamkasem and Morris 2016), liquid–liquid microextraction (LLME), liquid–liquid extraction (LLE), hollow-fiber liquid-phase micro-extraction (HFLPME) and dispersive liquid–liquid micro-extraction (DLLME) and molecularly imprinted solid-phase microextraction (MISPE). However, these methods have some disadvantages such as emulsion formation, using a large volume of organic solvents, expensiveness and difficulty in the application of the method, long-term extraction time, instability of micro drop, reduction of solid-phase performance with time, and in some cases the lower accuracy (Donato et al. 2015, Orooji et al. 2021). Due to the mentioned problems, more compatible and environmental-friendly techniques like salting-out assisted liquid–liquid extraction (SALLE) are introduced. This extraction method is commonly used for the separation and pre-concentration of organic and inorganic analytes such as biological (Wang et al. 2011) and pharmaceutical compounds from aqueous matrices (Noche et al. 2011). The SALLE is based on LLE, in which a suitable amount of salt was added to a mixture of water sample and water-miscible solvent. The mixture solution was then shaken until the salt was dissolved, resulting in a separation of the solvent from the mixture and thus, the formation of a two-phase system and simultaneously, the target analytes were separated into the organic phase (Zhao et al. 2012). About, concerning the use of surface waters as a major source of drinking water in Khuzestan Province, there is a growing concern about the pollution of the Karun River, which is used as a major water supply source for agricultural, industrial, and urban uses in neighboring cities. Accordingly, the wastewater generated from agricultural activities is a major source of pollution in the Karun River. Literature shows that agricultural drainage waters, due to their large volume, are the most important sources of return water to the rivers, which have high levels of contaminants and nutrients (nitrate and phosphorus), and therefore are highly contaminated. The organic pollution load of Karun River is notably increasing due to the continuous decrease of Karun River flow as a result of the inter-basin transfer of water from the headwaters of the Karun and lack of management of municipal, agricultural and industrial wastewaters entering the Karun River. Therefore, it is necessary to monitor and quantify the concentrations of the used pesticides in the inlet and outlet of water treatment plants in Khuzestan Province. To the best of our knowledge, there have been no studies investigating the pesticide residues in the water treatment plants of Ahvaz city. Therefore, the present study aimed to investigate the concentrations of 2,4-D in water treatment plants numbers 1, 2, 3, 4, and 5 of Ahvaz city during four seasons of autumn, winter, spring, and summer. For this purpose, the samples were collected before, during, and after cultivation and then analyzed using the SALLE method coupled with high-performance liquid chromatography (HPLC) for accurate and sensitive determination of the target pesticide. Eventually, the measured values were compared with water quality standards in Iran and WHO guidelines, to determine the quality of the drinking water consumed by the population. Due to the widespread application of 2,4-D in Khuzestan Province, its high stability, and high solubility in water, this pesticide was chosen as an indicator of agricultural pesticides.

Methods

Sampling procedures

In this descriptive cross-sectional study, the concentrations of 2,4-D in the inlet (raw water) and outlet (treated water) of Ahvaz treatment plant nos. 1, 2 (as the main treatment plants of Ahvaz city), 3, 4, and 5, were measured and investigated for 10 consecutive months (from December 2018 to September 2019). The characteristics of raw water are presented in Table 1. Figure 1 presents the study areas and locations of sampling sites on city map. A total of 200 water samples were collected and analyzed, by an interval of two weeks. According to the official reports and interviewing with the farmers, spraying was carried out in December, January, and February every year. S1 (Supplementary 1) presents the geographical locations of the studied water treatment plants including Ahvaz water treatment plants nos. 1, 2, 3, 4, and 5.
The first samples were taken from the raw water in the inlet of the treatment plants before the cropping season to determine 2,4-D concentration. Several samples were also taken from the operational and process units of the treatment plants and then analyzed. All samples were taken and stored under the Standard Methods for the Examination of Water and Wastewater (APHA 2017). Before sampling, all sampling containers were washed with detergent and twice distilled water. Then, the containers were completely washed with methanol and acetonitrile. Finally, the washed containers were heated in an oven at...

**Table 1.** Chemical and physical characteristics of Karun River water.

| Parameters       | Unit  | Value | Parameters       | Unit  | Value |
|------------------|-------|-------|------------------|-------|-------|
| EC               | μS/cm | 1793  | SO₄²⁻           | mg/L  | 359.3 |
| Temperature      | °C    | 20.5  | PO₄³⁻           | mg/L  | 0.02  |
| Turbidity        | NTU   | 140   | F⁻               | mg/L  | 0.49  |
| Total water hardness | mg/L (CaCO₃) | 443.98 | NH₃⁺           | mg/L  | 0.04  |
| Ca²⁺             | mg/L  | 116.23| NO₃⁻           | mg/L  | 0.044 |
| Mg²⁺             | mg/L  | 37.44 | NO₂⁻           | mg/L  | 0.044 |
| Cl⁻              | mg/L  | 287.16| TDS             | mg/L  | 1160  |
| Na⁺              | mg/L  | 0.018 | TSS             | mg/L  | 51    |
| pH               | –     | 7.8   | DO              | mg/L  | 7.5   |
| Alkalinity       | mg/L (CaCO₃) | 149.97 | AL₃⁺           | mg/L  | <0.006 |
| Bicarbonate      | mg/L (CaCO₃) | 182.96 | Fe              | mg/L  | <0.01 |
| 2,4-D            | μg/L  | 3     | TOC             | mg/L  | 3.59  |
| Organic content  | mg/L (KMnO₄) | 11.06 |                 |       |       |

**Figure 1.** Location of sampling sites on city map. WTP1, 2, 3, 4, and 5: water treatment plants numbers 1, 2, 3, 4, and 5 of Ahvaz city.
400 °C for 2 h (Acero et al. 2008). The solution pH of the samples was reduced to 2 at the sampling site using hydrochloric acid. S2 presents a summary of common operations and processes used in the studied water treatment plants.

Solvents and chemicals

In this study, all chemicals used were of analytical grade. 2,4-Dichlorophenoxyacetic acid (C₈H₆Cl₂O₃) with a purity of 99% (CAS number 94-75-7) was provided from Merck Co. (Darmstadt, Germany). Organic solvents used including acetonitrile, methanol, acetic acid, and twice distilled water with HPLC grade were purchased from Merck Co. (Darmstadt, Germany). Five percent sodium chloride (w/v), 0.02 N NaOH, 0.02 N HCl, and 2% sodium thiosulfate were also prepared and used. Standard buffers were used at three different pH levels (7 ± 0.02, 4 ± 0.04, and 9 ± 0.02) and provided from Merck Co. (Darmstadt, Germany). A stock solution of 2,4-D at a concentration of 1000 ppm was prepared by dissolving an appropriate amount of its pure substance in acetonitrile. The standard solutions used during the experiment were prepared daily by diluting the stock solution with acetonitrile.

2,4-D analysis

An HPLC (Knauer, Berlin, Germany) equipped with C-18 column (250 mm × 4.6 mm, with 5 μm particle size) was used for the separation of the 2,4-D pesticide. The HPLC was applied with a k-1001 pump, UV-Vis detector, and a k-2600 degasser. The chromatographic conditions were as follows: a C-18 column was used as the stationary phase, mobile phase consisted of acetonitrile, deionized water, and acetic acid at the ratios of 80:19.5:0.5, respectively. The HPLC was operated under the mobile phase flow rate of 1 mL/min, column temperature of 40 °C, and a maximum pressure of 40 MPa. The appropriate wavelength for the chromatographic peak area response of the analyte was 283 nm. An ultrasonic bath (SonoSwiss SW 6 H, UK) was utilized for the sample preparation. A pH meter device (model 340i, WTW, DE) and a digital scale with a precision of 0.0100 mg (Sartorius, Göttingen, DE) were used for measuring solution pH and weight measurements, respectively. A UV-vis spectrophotometer (model DR5000, HACH, US) was applied for measuring the concentrations of 2,4-D. A magnetic stirrer (model 50200-26, Cleaver, KR) was used for sample preparation. The samples were also filtered using filter paper 0.45 Watson Micron (GF/C, Wattmann Co., DE). A Hamilton HPLC syringe (100 μL, CH) was used for injecting the samples into the HPLC system.

Statistical analysis

The results were analyzed using Excel and Minita (version 16) and the mean 2,4-D concentrations were compared with the permissible limit recommended by the Iran National Standard (no. 1053) and WHO using t-test (one-sample test) (Pohanish 2014). One-way ANOVA test was also used to compare the mean 2,4-D concentration between different sampling sites and seasons.

Results and discussion

Validation of 2,4-D analysis method

The samples were prepared according to the method 515/3 recommended by the USEPA for pesticide measurements, method 6640B for detection of chlorophenoxy acid herbicides and the standard methods for the examination of water and wastewater (Domino et al. 2003, Acero et al. 2008, APHA 2017).

In this study, 2,4-D pesticide was extracted using acetonitrile solvent and a salt (NaCl). After extraction, the supernatant (organic phase) was transferred to a special vial using the Hamilton syringe and dehydrated with sodium sulfate without water. The final volume was reduced to 0.8 mL, and eventually 20 μL of the solution was injected into the HPLC device. The accuracy of the method was evaluated by conducting the recovery tests to avoid measurement errors. A specific amount of standard solution was spiked with the analyte to a concentration lower than the limit of detection (LOD). All tests were conducted with three replications. A maximum absorption wavelength (λ_max) of 283 nm was used to measure the concentrations of 2,4-D, which was previously determined using the DR5000 spectrophotometer (S3).

The peak area responses of the analyte of interest were identified by comparing the retention time of the analyte peak with the pesticide standard. Then, standard working solutions with concentrations of 0.01, 0.5, 1, 5, 10, 25, and 50 μg/L were prepared by diluting the stock solution (1000 μg/L) with acetonitrile. On consecutive days, 20 μL of the sample was manually injected into the HPLC device using a Hamilton syringe under similar operational conditions. The residual concentrations of 2,4-D were estimated based on the peak area response of analyte by plotting the calibration curve. The peak area response of 2,4-D was appeared at the retention time range of
3.4–3.7 min. The total run time was 10 min. The calibration curve was plotted with $R^2 = 0.9999$. Limit of detection and limit of quantitation (LOQ) were 0.004 μg/L and 0.01 μg/L, respectively. Also, the proposed method was evaluated to validate its application for the determination of the target pesticide. To ensure the accuracy of the measurements, a control sample was analyzed and no peak was observed in its chromatogram.

In this study, the residual concentrations of 2,4-D in real samples were measured by plotting a calibration curve of peak area responses versus analyte concentrations. The SALLE was used for the extraction and analysis of 2,4-D in the inlet and outlet of water treatment plants nos. 1, 2, 3, 4, and 5 of Ahvaz city. The mean concentrations of 2,4-D in the samples were reported. S4 shows the chromatogram of a sample collected from treatment plant no. 2 before and after spiking it with a standard solution of 2,4-D. As observed, the chromatogram indicated that the used method offered an appropriate performance for pesticide separation. Moreover, the accuracy and precision of the used method were evaluated by adding a given concentration of the analyte to the samples in binary (laboratory fortified matrix (LFM) and laboratory fortified matrix duplicate (LFMD)). Then, the recovery percentage of the analyte of interest was evaluated by the studied methods. The related results are shown in Figure 2. In these samples, the recovery percentages of 2,4-D were 95.98% and 115% using laboratory fortified matrix and laboratory fortified matrix duplicate methods, respectively. Moreover, according to the graph and obtained results, the analyte was categorized in the range of 93.99–117.35% mineralization and the difference between laboratory fortified matrix and laboratory fortified matrix duplicate was less than 20%. Therefore, the method had a high accuracy and precision for the deception of 2,4-D. Also, these results are consistent with the findings of Chamkasem and Morris (2016), Donato et al. (2015), and Wen et al. (2015) studies (Donato et al. 2015, Wen et al. 2015, Chamkasem and Morris 2016).

Comparison of the measurement results of 2,4-D concentrations using the SALLE method with other methods indicated that the SALLE offered a high accuracy and sensitivity for measuring 2,4-D content in water samples. Moreover, the results implied that the SALLE method had lower LOD and LOQ compared with LLE and SPE methods. In addition, the proposed extraction method had a wider linear range of over other conventional methods. Some other advantages of this method include simple use and short extraction time, which are very important parameters in developing analytical methods. S5 compares the performance of the proposed extraction method with other methods (De Beer and Joubert 2010, Donato et al. 2015, Wen et al. 2015, Chamkasem and Morris 2016).

**Variations of 2,4-D in Karun River**

After analysis of the samples using the HPLC apparatus, the results of different sampling sites were compared. Figure 3 shows the variations of 2,4-D concentrations at different months in the Karun River sampling stations. According to the results, residual concentrations of 2,4-D in all treatment plants were
These results implied that the mean concentration of 2,4-D residues gradually decreased over time (from the second week of February to mid-April), and then from mid-April to late-September, its levels reached below the LOD of the HPLC device. Statistical analysis of data showed that there was a significant difference between residual 2,4-D concentration and the time ($p$ values $< .05$). The highest and lowest concentration of 2,4-D in all sampling sites within the study were ranged between 5.68 ppb (December) and 0.004 ppb (May–September) (Table 2). Based on the results, the mean 2,4-D concentrations in autumn, winter, spring, and summer were 3.93, 2.44, 0.052, and 0.004 μg/L, respectively. As observed, the total 2,4-D concentrations in autumn, winter, and spring were in the range $< 0.004–5.68$, 0.02–5.59, and 0.004–0.096 μg/L, respectively. Moreover, no 2,4-D pesticides were detected in summer. This phenomenon can be attributed to the decrease in the 2,4-D concentration over time and relatively low stability of these pesticides under the environmental conditions.

These values were lower than the concentrations recommended by the Iran National Standard (no. 1053) and WHO, indicating the high quality of raw water in the studied water treatment plants. Therefore, the self-purification capacity of the Karun River can appropriately reduce these types of pollutants. Due to its strategic location of Karun River, it is a major water supply source for agricultural, industrial, and urban uses. Temperature also affects the hydrolysis rate of pesticides, which was increased 3.75-fold for every 10°C increase (Orooji et al. 2020). According to experiments, the minimum and maximum water temperature at sampling sites was 17 and at 29°C, which can affect the reduction of pesticide residues in the water.

As observed in Figure 3, the 2,4-D concentration decreased significantly after the cultivation season, which could be due to the decrease in the 2,4-D concentration over time and relatively low stability of these pesticides under the environmental conditions. The high concentration of 2,4-D in most sampling sites from December to early-April was attributed to the widespread application of this pesticide in the surrounding gardens and agricultural lands. Moreover, the application of 2,4-D in soluble form facilitates its entry into the river. These results are consistent with the findings of Arjmandi et al. (2010) study, in which two phosphorus insecticides were measured in the waters of the Simineh Rood and Mahabad rivers in West Azerbaijan, Iran. They reported that the pesticides were only observed in the growing and spraying season of plants and were not detected in other seasons (Arjmandi et al. 2010). In another study that was conducted by Dehghani et al. (2012) on the identification of diazinon and chlorpyrifos as two organophosphorus pesticides in the water resources of Barzak city.
of Kashan, it was found that one month after spraying their residual concentrations were higher than the permissible limits (Dehghani et al. 2012). According to the one-way ANOVA test, the mean concentration of total 2,4-D between the four seasons of autumn, winter, spring, and summer was compared. The results implied that there was a statistically significant difference between summer and spring, autumn and winter, and summer and spring (p < .05). There was no significant difference between the autumn and winter seasons (p value > .05). In a study conducted by Petitta and Marino, on water management in the Fusino Plain in Italy in 2010, the results showed that rainfall and irrigation play an important role in transmitting pesticides to groundwater and surface water resources (Petitta and Marino 2010). It should be noted that despite the decrease in the pesticide concentration in the autumn and winter compared with the spring and summer seasons, the 2,4-D concentration had an increasing trend and this may be attributed to the heavy rainfall in winter with the cultivation and washing of agricultural soils and the transfer of pesticide residues from the soil to surface water. Moreover, the lack of new irrigation methods can cause the transfer of pesticides from these areas to the water resources (Fosu-Mensah et al. 2016). Sobhanardakani and Jamalipour (2017) determined the residual concentration of some organochlorine and phosphorus-containing pesticides in Gargar River water and concluded that the mean concentration of atrazine pesticide residues in the studied samples was not significantly higher than the permissible limit. However, the difference between the residual concentrations of alachlor and 2,4-D pesticides in the samples was significantly lower than the permissible limit recommended by the Iran National Standard and WHO. Also, there was no significant difference in the residual concentrations of 2,4-D pesticide between different sampling sites (Sobhanardakani and Jamalipour 2017).

2,4-D Removal in water treatment plants

The mean total concentrations of 2,4-D in the inlet and outlet of the studied water treatment plants were in the order of no. 5 > no. 4 > no. 3 > no. 1 > no. 2. According to the one-way ANOVA test, comparing the mean total concentration of 2,4-D residues, there was no significant difference between the five treatment plants (p value > .05) while there was a significant difference between the inlet and outlet of each treatment plant (p value < .05).

| Table 3. Comparison of the mean total concentration of 2,4-D and their reduction percentages at different stages of the treatment plants. |
| --- |
| WTP | Raw water Mean (ppb) | Clarification Mean (ppb) | Effluent Mean (ppb) |
| --- | --- | --- | --- |
| 1 | 3.06 | 1.99 | 1.03 |
| 2 | 2.89 | 1.79 | 0.89 |
| 3 | 3.16 | 2.15 | 1.17 |
| 4 | 3.57 | 2.59 | 1.56 |
| 5 | 3.68 | 2.64 | 1.63 |
| %Removal | 34.97 | 69.20 | 56.30 | 55.71 |

*Water treatment plant.*

The conformity of the distribution pattern of pesticide concentration in all treatment plants indicated the similarity of pesticide consumption patterns in agricultural lands around the river adjacent to treatment plants. The similarities of the physical and chemical properties of the farm water may be because these areas are located in an area with similar geographic and climatic characteristics (Arjmandi et al. 2010).

Table 3 presents the mean total concentrations of 2,4-D in all studied samples and the reduction percentage at different stages of the treatment plants. According to the results, the total concentration of 2,4-D in all studied samples was lower than the recommended values by the Iranian National Standard (30 ppb) and WHO (70 ppb). A comparison of mean concentrations of 2,4-D at sampling sites showed that there was a significant difference between the mean concentrations of 2,4-D in the five water treatment plants and standard values (p < .001). Therefore, it can be concluded that the residual concentration of 2,4-D in water samples taken from the inlet and outlet of the treatment plants does not cause adverse effects on human health. The results indicated the presence of 2,4-D pesticide residues in the inlet and outlet of Ahwaz treatment plants in the cultivation season and a dramatic reduction in the pesticide concentration at different stages of treatment plants. The maximum removal efficiency of the 2,4-D pesticide was in the order of treatment plant no. 2 > no. 1 > no. 3 > no. 4 > no. 5. The 55% decrease in the pesticide concentration indicated the performance of the treatment plants (coagulation, sedimentation, and filtration) in the removal of priority chemical contaminants. Therefore, by optimizing the conventional processes such as coagulation, sedimentation, and filtration, they can improve the chemical properties of water in addition to reducing physical contamination such as turbidity. Rabiei Rad et al. investigated the effect of water treatment process on the residual concentration of some chlorinated organic pesticides in Ahwaz Water Treatment Plant No. 2 and concluded that the
reduction percentage of pesticide residues at different stages of the treatment process was in the range the 20–80%. Moreover, the mean total concentration of the studied pesticides decreased by 49% (Majd et al. 2017). Our results are in agreement with the findings of Kalantari et al. (2016).

Given the problems to the use of modern technologies such as ozonation and reverse osmosis in developing countries, increasing the efficiency of conventional treatment processes should be considered a high priority. Literature suggested that further studies are required to optimize and increase the efficiency of the conventional processes such as the use of activated carbon in coagulation for the elimination of chemical contaminants, establishing strategies for managing crisis and water management, prevention of contamination of water resources through reducing the use of pesticides and fertilizers in agriculture, especially persistent and durable pesticides in the environment, and control of industrial and urban wastewater, especially in the Ahwaz city, which is directly discharged into the Karun River. Hence, it is necessary to manage and monitor the strategies to provide high-quality water, which has no adverse effect on consumer health. Since these pesticides are stable and remain in the environment for a long time, they accumulate in biological tissues due to their lipophilic and hydrophobic properties and low chemical and biological degradation rate, and thereby enter the food chain at high concentrations. Therefore, it is necessary to monitor the residual concentrations of these pesticides regularly in Iran.

Conclusions

In this paper, the SALLE method was successfully used for preconcentration and extraction of trace levels of 2,4-D pesticides in water samples. The proposed method offered many advantages such as simplicity, good accuracy, short extraction time, high sensitivity, low cost, and requiring simple equipment for 2,4-D extraction and analysis. Therefore, this technique can be used as a convenient, rapid, and sensitive method to monitor 2,4-D concentrations in aqueous samples. Moreover, the measurement results showed that the 2,4-D concentrations in the inlet and outlet of treatment plants nos. 1, 2, 3, 4, and 5 of Ahwaz city were lower than the permissible limit recommended by the national standard of Iran (1053) and WHO. Also, the results showed that there was no significant difference in the mean 2,4-D concentration in the five studied water treatment plants, while there was a significant difference in 2,4-D concentration between the inlet and outlet of each studied treatment plant. Therefore, the treated water in the distribution network of Ahvaz city does not cause adverse effects on human health. The most significant result that can be derived from the 69.2% reduction in the total poison concentration is the importance of the common treatment processes (coagulation, settlement, and filtration) in reducing the chemical contaminants. Hence, by optimization of such processes as coagulation, settlement, and filtration, it is possible not only to reduce physical contaminants (turbidity), but also to improve the chemical desirability of water. With respect to the difficulties, that using such modern technologies as advanced oxidation processes and reverse osmosis create in developing countries increased efficiency in the common treatment processes can be posed as a higher priority. Since the drinking water in Ahvaz city and other surrounding cities is supplied from Karun River, it is necessary to monitor the residual concentrations of the most commonly used pesticides in different seasons, especially in fall, winter, and spring that the pesticides and fertilizers are widely used in agriculture.

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