

Monitoring of some quality parameters of drinking water treatment plant in Beheria Governorate

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ABSTRACT

Chemical studies were performed of water samples collected from October 2011 to September 2012 from Kafer El Dawar water treatment plant in El- Behira Governorate, Egypt, in order to cover the seasonal variations during one year. This period covers all operational changes and weather conditions. This monitoring was established for measuring heavy metals such as [iron (Fe), manganese (Mn), copper (Cu), zinc (Zn), lead (pb), arsenic (As)], these parameters measured by (ICP-OES). and other operational parameters including temperature, pH, turbidity, nitrite ,nitrates , ammonia, fluoride and residual chlorine of both raw and treated water by using IC-Dionex 600 .

Key words: heavy metals, drinking water, water quality, treatment plant, Egypt.

INTRODUCTION

Safe and good quality drinking water is the basis for good human health. Water provides some elements, but when polluted it may become the source of undesirable substances dangerous to human health and cause disease such as, various cancers, adverse reproductive outcomes, cardiovascular disease and neurological disease. Therefore the heavy metal concentration in drinking water should be kept in the low ppb range. The drinking water quality is associated with the conditions of the water supply networks, the pollution and contamination of groundwater with pollutants of both anthropogenic and natural origin (Kalpan *et al.*, 2001).

Metals make up a large portion of the inorganic pollutant found in water. The utilization of metals by humans influences the potentials for adverse health effects. Metals are neither created nor destroyed but are redistributed naturally in the environment by both biological and geological cycles. Erosion from soils and addition from industrial activities introduce metal into surface water in which metals can find their way into food chain (Ewane 1998).

The accelerated industrialization process in combination with rapid population growth and agricultural activities has brought the risk of increasing the pollution index in natural environments, such as water, soil, air, etc. (Assubaie 2011).

Some of heavy metal like copper (Cu), and zinc (Zn) are essentially required for normal body growth and functions of living organisms, while the high concentrations of other metals like manganese (Mn) and lead (Pb) are considered highly toxic for human and aquatic life, high concentrations of Mn and Cu in drinking water can cause mental diseases such as Alzheimer's and

Manganism, high Mn contamination in drinking water also affects the intellectual functions of 10-year-old children (Muhammed *et al.*, 2011).

Pb is also a highly toxic and carcinogenic metal and may cause chronic health risks, including headache, irritability, abdominal pain, nerve damages, kidney damage, blood pressure, lung cancer, stomach cancer and gliomas. As the children are most susceptible to Pb toxicity, their exposure to high levels of Pb cause severe health complexities such as behavioral disturbances, memory deterioration and reduced ability to understand, while long-term Pb exposure may lead to anemia, like other heavy metal, Zn deficiency can lead to poor wound healing, reduced work capacity of respiratory muscles, immune dysfunction, anorexia, diarrhea, hair loss, dermatitis and depression. While Zn toxicity causes anemia (Karavoltzos *et al.*, 2008).

Other types of inorganic pollutants happen to be nonmetals and they also, cause adverse health effects to humans and affect the environment. These nonmetallic pollutants include, nitrate, phosphate, and fluoride. Nitrates and fluorides can influence human health, while nitrates and phosphates can also cause environmental damages in the form of eutrophication of lakes and ponds. The accumulation of nitrates in the environment has been enhanced due to heavy reliance on nitrogenous fertilizers in agriculture. Nitrogenous wastes from livestock and poultry production have also contributed to the increased load of nitrates in both soil and water. Nitrates can contaminate groundwater to unacceptable levels of >10 mg/L. While nitrate itself is relatively innocuous, it can be reduced to nitrite by microbes in the intestines. Particularly, in the intestines of young children. Nitrite reacts with secondary amines in the digestive tract to produce nitrosamine, which is a carcinogen (Munavalli *et al.*, 2005)

The objective of this study is to monitor the concentrations of some quality parameters particularly heavy metals in raw surface water and treated water from water treatment plant in Beheria Governorate and compare results with the Egyptian and international guidelines.

MATERIALS AND METHODS

Sampling

Water sampling from Kafr El-Dawar water treatment plant in EL-Behira governorate, Egypt, was conducted monthly between 10 and 20th each sampling day, from October 2011 to September 2012. Monthly results expressed as an average for three replicates of samples. This water treatment plant is of conventional design; major features include coagulation, flocculation, sedimentation and filtration. Chlorination is the only technique used for the disinfection of water. The pre-chlorination is applied in the coagulation channels and the post-chlorination is applied before the entrance of water to finished water reservoir in distribution system, so chlorine dose

applied as the sum of pre-chlorination and post-chlorination. The only coagulant used is Aluminum Sulfate (Egyptian alum) each plant has its own specific dose.

Samples were collected in 1 liter plastic bottle refrigerated and transferred to the laboratory for measurement of physical and chemical parameters. Certain parameters such as the temperature, residual chlorine and pH were determined in the field immediately by using HACH portable pH meter.

Reagents

Analytical reagent grade chemicals were used purchased from (HACH, Sigma-Aldrich, Chemlab, Merck, Scharlau, Panreac and Ultrascintific) without further purification. Ultra pure water was used for blank and standers preparation.

Determination of physical and chemical parameters in water samples

All measurements were carried out according to the Standard Methods for the Examination of Water and Waste Water. (APHA, AWWA, WEF, 2005).

Temperature and pH were measured for raw surface and treated water by using portable HACH multi-parameter. Residual chlorine was determined for treated water by photometric method (S.M. 4500-Cl G) using HACH colorimetric. Turbidity was measured for surface and treated water using HACH 2100N turbidity meter (S.M.2130B).

Determination of inorganic parameters in water samples

The fluoride (F), Nitrite (NO₂), Nitrate (NO₃) and ammonia (NH₃) were performed by using (Dionex-600) ion chromatography equipped with electrochemical detector (ECD-50), Isocratic pump (IP25). These measurements were performed according to EPA 300.1 method (USEPA, 1997).

Standers and Calibration

A calibration curve was carried out at five calibration standard levels, starting with limit of quantification (LOQ) as first standard, midpoint which is used as a validation standard at the beginning of each sequence and another three standard levels at different concentrations also used. Two calibration standards at different concentration levels analyzed at the beginning and the end of sample set. Before processing any samples, blank sample analyzed at the beginning of calibration curve and at the beginning of each sample sequence to demonstrate that all glassware and reagent interferences are under control. After processing calibration standards a verification standard is measured to determine recovery percentage.

Measurement of Heavy metals in water samples

Inductively Coupled Plasma Optical Emission Spectroscopy (ICP-OES) is a destructive technique which can be used for the determination of nearly all elements. The elements of interest are iron (Fe), manganese (Mn), copper

(Cu), zinc (Zn), lead (pb), arsenic (As). Analysis performed according to EPA method 200.7 (USEPA, 1994).

Sample collection and preservation

The water samples were made acidic ($\text{pH} < 2$) with concentrated nitric acid (65%w/w), in order to minimize chemisorptions and hydrolysis of metal ions, and preserved at 4°C in the refrigerator for the metal analysis.

Procedure

100ml measured volume were transferred to a beaker. Add 5ml of conc. HNO_3 . Bring to a slow boil and evaporate on a hot plate to about 10ml before precipitation occurs. Do not let sample dry during digestion. Wash down beaker wall with metal-free water. Transfer to 100ml volumetric flask. Cool, dilute to mark and mix.

Calibration and quality control

Blank sample analyzed to demonstrate that all glassware and reagent interferences are under control. A calibration curve was set at five calibration standard levels. Two calibration standards at different concentration levels analyzed at the beginning and the end of sample set.

Method validation and uncertainty

LOQ, method accuracy and precision were performed according to the specified condition of the method and consist of analysis of laboratory reagent blank, fortified blank and samples as continuing check and performance. This evaluation based on EURACHEM Guide (Eurachem, 1998). The LOQ may be defined as the concentration of the analyte which give 5 or more signal to noise ratio. The % recovery, which is an estimation of accuracy, is calculated for lowest, mid-point and higher standard level and averaged to obtain the mean % recovery. To estimate precision, % relative standard deviation (% RSD) is calculated by dividing the standard deviation of replicates of each level and then multiplying by 100%. From these accuracy and precision results, method uncertainty estimated based on EURACHEM for quantifying uncertainty (Eurachem, 2000).

All results were expressed as mean \pm SD. The Microsoft Excel was used for the graphical presentation and correlation.

RESULTS AND DISCUSSION

Physico-chemical parameters

Treated water results shown in Table 1. In all raw surface water samples, the pH values ranged between (8.3-7.81) with average values (8.06 ± 0.15), in treated water pH values ranged between (7.32-7.06) with an average values (7.21 ± 0.13). Results obtained for pH are in agreement with the results obtained by Kim *et al.* (2011) and Cheng *et al.* (2003).

Temperature for raw surface water ranged through all seasons between ($16.2-24^\circ\text{C}$), with an average value ($20.38^\circ\text{C} \pm 2.7$), while in treated water

values ranged between (17-24.4°C) with an average value (20.57 °C ±2.56). This is similar to results obtained by Deborde and Gunten (2008).

Turbidity values of raw surface water ranged between (25.9-11.6 NTU) with an average values of (19.39 NTU ± 4.42), however in treated water values were (1-0.76 NTU) with an average values of (0.92 NTU±0.08).

Ammonia results of raw surface water ranged between (1.12 - 4.56 mg/L) with an average values of (1.74 mg/L ±1.38), in treated water ammonia ranged between (ND - 3.1 mg/L) with an average values of (1.4 mg/L ±1.01). Results were higher than the maximum contaminant level (MCL). This plant water intake is highly polluted from EL Rahawy sewage system which is highly contaminated with industrial and agricultural wastes. The ammonia concentrations in surface water affected by hydrogeology, climate change and human activities, also changing seasonally in different drinking water sources, and varying in various regions due to geological permeability and the natural features of regions. Ammonia increases naturally in winter these results are in agreement with results obtained by Fu *et al.* (2012) who found that ammonia also increases during winter, also complies with results obtained by Zhen *et al.* (2007).

Nitrite results of raw surface water ranged between (ND -0.75 mg/L) with an average value (0.52 mg/L ±0.21), however in treated water results became not detected. This complies with Yang and Cheng (2007). Who found nitrite levels in drinking water can be controlled by chlorination and chloramination. For chlorination treatment, residual chlorine level of 0.3 mg/l Cl₂/l can ensure 99% nitrite oxidation under typical treatment condition. In chloramination, Cl₂: N ratio of 6:1 and residual chlorine of 0.7 mg/L is sufficient to cause oxidation of most of nitrite in water with near neutral pH. Nitrite levels should meet drinking water standers after such oxidation treatment.

Nitrate results for raw surface water ranged between (4.5-2.29 mg/L) with an average value (3.53 mg/L ±0.81), in treated water results ranged between (5.98-3.45 mg/L). With an average value (4.51 mg/L ± 0.92). These results are in agreement with the results obtained by Mesa *et al.* (2003) and similar to results obtained by Yang and Cheng (2007).

Fluoride results ranged from (0.59-0.25 mg/L) with an average value (0.41 mg/L ± 0.1) while in treated water results ranged between (0.45-0.21 mg/L) with average value (0.36 mg/L ± 0.07). This complies with Turner *et al.* (2005). Who Examined fluoride concentration in drinking water and found that results ranged from 0.25mg/L to 0.86 mg/L, and with the results obtained by Raichur and Basu (2001) who found all results were below WHO guidelines

Heavy metals result

Treated water results shown in Table 2. Fe concentrations for raw surface water ranged between (0.83-0.39 mg/L) with an average value (0.61 mg/L±0.14), in treated water concentrations ranged between (0.11-0.03 mg/L),

with average value (0.07 mg/L \pm 0.02). These results are in agreement with Mora *et al.* (2009) and Abesser *et al.* (2006).

Mn results for raw surface water ranged between (0.32-0.12 mg/L), with an average value (0.2 mg/L \pm 0.07), however in treated water results ranged between (0.07-0.01 mg/L) with an average value (0.04 mg/L \pm 0.02). These results comply with Kavcar *et al.* (2009) and Nerbrand *et al.* (2003).

Figure 1 shows correlation between turbidity and iron with correlation 0.829. These results were in agreement with Imran (2003). He explains that this correlation is due to Iron rust and corrosions released in the form of turbidity also iron always attached to turbidity constituents. Figure 2 shows zinc concentration in raw and treated water. This due to presence of zinc in alum which used in treatment as coagulant.

As concentrations for raw surface water ranged between (2.98-1.53 μ g/l), with average value (2.07 μ g/l \pm 0.47), while in treated water values ranged between (0.14-0.03 μ g/l), with average value (0.09 μ g/l \pm 0.03). These results are in agreement with results obtained by Jovanovic *et al.* (2011).

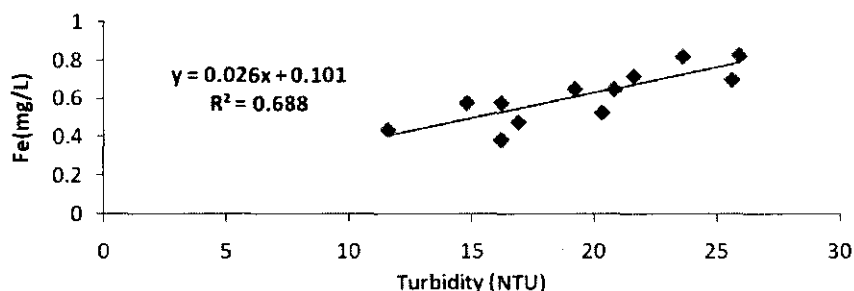


Figure1: Regression between iron and turbidity in raw water

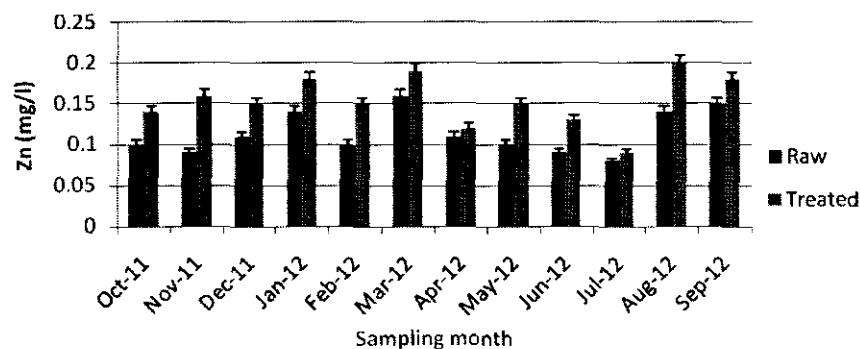


Figure 2: Zn concentration in raw surface and treated water

Table 1: Seasonal variation of the physico-chemical parameters in treated water

Parameter	Unit	Autumn ^a		Winter		Spring		Summer	
		Range	Mean ± SD ^b	Range	Mean ± SD	Range	Mean ± SD	Range	Mean ± SD
Temp	°C	17.2 - 19	17.7 ± 1.1	17 - 20.5	18.9 ± 1.6	21.2 - 22.8	21.8 ± 0.8	23 - 24.4	23.7 ± 0.7
pH		7.1 - 7.3	7.23 ± 0.09	7.19 - 7.23	7.2 ± 0.02	7.08 - 7.2	7.13 ± 0.06	7.06 - 7.54	7.27 ± 0.25
Turbidity	NTU	0.91 - 1	0.96 ± 0.05	0.83 - 0.94	0.9 ± 0.06	0.76 - 1	0.91 ± 0.13	0.81 - 1	0.91 ± 0.1
NH ₃	mg/L	0.6 - 0.9	0.8 ± 0.19	1.58 - 3.1	2.3 ± 0.76	ND	NA	ND	NA
NO ₂	mg/L	ND ^c	NA ^d	ND	NA	ND	NA	ND	NA
NO ₃	mg/L	4.2 - 5.4	5.02 ± 0.71	3.5 - 3.6	3.6 ± 0.09	3.5 - 4.9	4.24 ± 0.72	4 - 5.98	5.2 ± 1.05
F	mg/L	0.38 - 0.42	0.4 ± 0.02	0.36 - 0.45	0.41 ± 0.05	0.21 - 0.4	0.3 ± 0.1	0.25 - 0.39	0.32 ± 0.07

a: Autumn (Oct to Dec2011), Winter (Jan to March2012), Spring (Apr to Jun2012) Summer (Jul to Sep 2012) b: Mean± Standard deviation, c-ND: Not detected, d- NA: no assigned value

Table 2: Seasonal variation of heavy metals concentration in treated water.

Parameter	Unit	Autumn ^a		Winter		Spring		Summer	
		Range	Mean ± SD ^b	Range	Mean ± SD	Range	Mean ± SD	Range	Mean ± SD
Fe	mg/L	0.07 - 0.11	0.09 ± 0.02	0.03 - 0.08	0.05 ± 0.03	0.04 - 0.1	0.06 ± 0.03	0.06 - 0.08	0.07 ± 0.01
Mn	mg/L	0.03 - 0.05	0.04 ± 0.01	0.04 - 0.07	0.06 ± 0.02	0.04 - 0.06	0.05 ± 0.01	0.01 - 0.03	0.02 ± 0.01
As	µg/L	0.1 - 0.12	0.11 ± 0.01	0.1 - 0.13	0.11 ± 0.02	0.08 - 0.14	0.11 ± 0.03	0.03 - 0.06	0.04 ± 0.02
Zn	mg/L	0.06 - 0.15	0.12 ± 0.05	0.15 - 0.19	0.17 ± 0.02	0.12 - 0.15	0.13 ± 0.02	0.09 - 0.2	0.16 ± 0.06
Pb	µg/L	0.01 - 0.08	0.04 ± 0.04	0.03 - 0.07	0.05 ± 0.02	0.02 - 0.06	0.04 ± 0.02	0.04 - 0.09	0.07 ± 0.04
Cu	mg/L	ND	NA	ND	NA	ND	NA	ND	NA

a: Autumn (Oct to Dec2011), Winter (Jan to March2012), Spring (Apr to Jun2012) Summer (Jul to Sep 2012) b: Mean± Standard deviation, c-ND: Not detected, d- NA: no assigned value

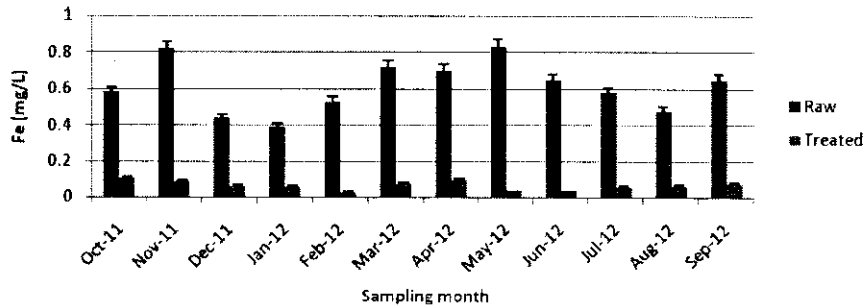


Figure 3: Iron concentration in raw surface and treated water

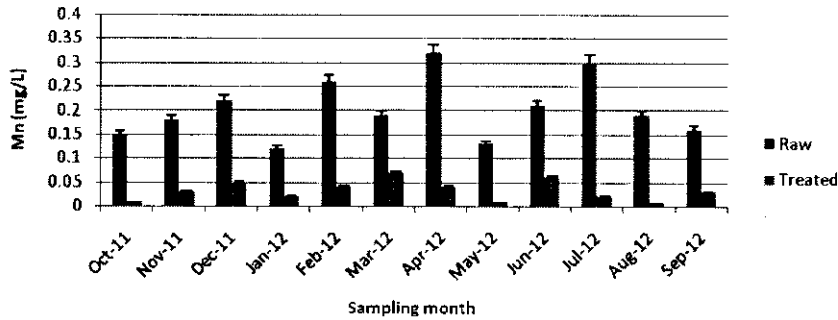


Figure 4: Manganese concentration in raw surface and treated water

Figure 3 shows iron concentration between raw surface water and treated water. This ensures the efficiency of treatment process in iron removal where chlorination was highly effective in iron oxidation under typical treatment conditions. These results were in agreement with Yang and Cheng (2007). This removal is also applied to manganese which indicated in Figure 4. Concentration of Zn for raw surface water ranged between (0.16-0.08 mg/L) with average value (0.11 mg/L \pm 0.03), in treated water values ranged between (0.2-0.06 mg/L), with average value (0.15 mg/L \pm 0.04). This could be associated with human activities which increases load of Zn release to water bodies such as use of chemicals and Zinc based fertilizers by farmers this complies with Chegrouche and Mellah (1997).

In addition to this, Pb concentration for raw surface water ranged between (3.5-1.56 μ g/l) with average value (2.36 μ g/l \pm 0.59), however treated water values ranged between (0.09-0.01 μ g/l) with average value (0.05 μ g/l \pm 0.03).

These results are in agreement with the results obtained by Mohamed *et al.* (1998) who studied lead concentration in raw and finished drinking water in Great Cairo in Egypt. The mean lead concentration in the raw water samples was 29.5µg/L. It was 9.9µg/L in the finished drinking water. They reported that the concentrations in the finished water were less than in the raw water. These data show that the filtration units used in the water treatment plants effectively reduce lead concentration in the river water. The percent reduction based on the overall mean concentrations was 33%.

Cu concentration for raw surface water ranged between (0.04-0.01mg/L), with average value (0.02mg/L ±0.01), in treated water in treated water all Cu results were not detected. This is in agreement with Mandour and Azab (2011) they found Cu results were not detected in drinking water samples.

CONCLUSION

This study showed that the contamination of all analyzed elements in water samples were within the WHO (2008) concentration guidelines and below the maximum contaminant level (MCL) established by USEPA (2002) and Egyptian health ministry in the decision number 458 at 2007 except for ammonia results which exceeds Egyptian MCL. Ammonia content of drinking water sources is mainly from wastewater drainages, and ammonia discharges from industries, urban areas, and nonpoint sources. Wastewater is the predominant contaminant source in most drinking water sources. So, in order to ensure drinking water safety, the management of wastewater should be strengthened, and traditional water treatment systems should be improved.

- The extremely low levels of the toxic heavy metals indicate that the water was not polluted.
- There was no seasonal variation between different parameters except for ammonia which increased during winter season
- Zinc occasionally increased in treated water and by making analysis for alum we found that it contain Zinc which explain increase Zn content in treated water than raw water.
- Appropriate monitoring programs should be established to ensure that the chemical quality of drinking water remains within accepted national standards and to maintain water safety for public use. Reduction of metals which have cumulative toxic hazards in drinking water is a necessity.

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الملخص العربي

رصد بعض عناصر الجودة لمحطة معالجة مياه الشرب بمحافظة البحيرة

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تعد سلامة مياه الشرب أساس لصحة الإنسان حيث تتوفر بها بعض العناصر الهامة ولكن عند تلوثها ببعض الملوثات مثل المعادن الثقيلة تصبح مصدر ضار لصحة الإنسان وتسبب لعديد من الأمراض ومنها السرطان، أمراض القلب والأمراض العصبية . لذلك هناك جهود متعددة لتقليل نسب هذه العناصر في مياه الشرب الى اقل تركيز ممكن فهذه المعادن تحتل النسبة الاكبر من نسبة الملوثات الغير عضوية الموجوده في البيئة عموما وفي مياه الشرب.

وفي هذه الدراسة تم رصد نوعية المياه وبعض المعادن الثقيلة شهريا في محطة كفر الدوار لمعالجة مياه الشرب بمحافظة البحيرة في الفترة من اكتوبر ٢٠١١ الى سبتمبر ٢٠١٢. تم سحب عينات من المياه الخام والمياه المعالجة وقد تم تقدير الخصائص الفيزيائية والكيميائية لهذه العينات مثل الكلور المتبقي ،الاس الهيدروجيني ودرجة الحرارة في مواقع اخذ العينات وقياس العكارة والامونيا والنيتريت والنترات والفلوريدات باستخدام الكروماتوجرافى الايوني. Dionex600 وقد تم قياس بعض المعادن الثقيلة مثل الحديد، المنجنيز، النحاس، الزنك، الرصاص والزرنيخ باستخدام جهاز ICP Perkin Elmer 7200

ومن الدراسة تبين ان جميع نتائج المعادن الثقيلة تقع ضمن الحدود المسموح بها لوزارة الصحة ومنظمة الصحة العالمية. الامونيا غير مطابقة للمعايير القياسية نظرا لوجود مصدر تلوث في مصدر المحطة من مصرف الرهاوى والذى يؤدي لزيادة تركيز الامونيا في فصل الشتاء .

وينبغي وضع برامج الرصد المناسبة لضمان جودة المواد الكيميائية الموجودة في مياه الشرب وبقائها في اطار المعايير الوطنية المقبولة والحفاظ على سلامة المياه للاستخدام العام و الحد من المخاطر التي تسببها المعادن السامة المتراكمة في مياه الشرب.