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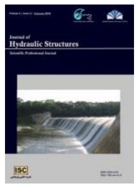

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Investigating the effect of point-of-use water treatment (POU) system on Urban Water Quality in IRAN: A systematic review

Seyedeh Tooba Mirsalari [1]
Hossein Sasani [2]
Mohammad Azizipour [1]
Neematollah Jaafarzadeh [3]

Abstract

In many developing countries, insufficient water treatment forces the people to use the home point of use (POU) systems. A scientific review was conducted for all articles published on POU for Iranian cities. This study focuses on the effect of the POU systems on water quality. The related data were collected according to the inclusion and exclusion criteria and by searching. Supported the searched keywords with emphasis on the type of water treatment system and the type of incoming water, the obtained articles were reviewed. The qualitative data were collected employing a preferred reporting items for systematic reviews and Meta-analyzes (PRISMA) standard checklist. 544 article titles were found within the initial search with the keywords listed. Finally, after reviewing the knowledge and quality of the articles, 20 articles were eligible for systematic review. the most important number of articles were published between 2012 and 2021. In some cities, EC, TDS and total hardness were high, which reached the specified standard after leaving the POU systems. But since these systems reduce all parameters and are not selective, they greatly reduce the quantity of chlorine, fluoride and sometimes TDS and pH. As chlorine decreases, the quantity of microbial contamination in the effluent increases. By reducing the fluoride within the effluent, the health of the teeth and bones is compromised over time. Therefore, on time replacement of all filters is essential and consumers and operators of these systems should be trained enough in the field of water quality standards and guidelines.

Keywords: Systematic Review; Point of Use; Household Water Treatment Systems; Water Quality.

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[1] Department of Civil Engineering, Faculty of Civil Engineering and Architecture, Shahid Chamran University of Ahvaz, Ahvaz, Iran.
[2] Department of Civil Engineering, Faculty of Civil Engineering and Architecture, Shahid Chamran University of Ahvaz, Ahvaz, Iran. E-mail: h.sasani@scu.ac.ir. (**Corresponding Author**)
[3] Environmental Technologies Research Center, Ahvaz Jundishapur University of Medical Sciences, Ahvaz, Iran.

1. Introduction

Access to safe and secure beverages is a fundamental human right [1].To achieve the sixth goal of sustainable development goals in order to have access to safe and hygienic drinking water, all communities are required to form progress towards this goal [2]. The global increase and lack of sufficient water resources make access to safe water difficult [3]. Also, the existence of economic and social inequalities, education and housing greatly impact the lack of access to safe water for humans [4][5]. thanks to the scarcity of drinking water in many parts of the world, there are major challenges to accessing water [6]. In developing countries, thanks to the lack of sufficient facilities and the intermittent water in the drinking water distribution system, people address collecting water in underground or rooftop tanks, this sort of water collection provides a suitable substrate for the growth of microbes [7].

In some cases, in urban water distribution pipes, thanks to low or negative pressure in the pipe, contaminants can enter the pipes from the surface of the pipe, because sewage may pass near the pipe or the encompassing soil may be contaminated. This shows that pollution enters the piped water from three places: 1- At the source and treatment plant 2- Distribution network 3- At the place of water consumption, in the houses and how to collect water [8]. One of the most common uses of water among people is the use of bottled water, tap water and point of Use (PoU) treated water [9][10]. Waterborne diseases are a concern in many developing countries for this reason, the use of bottled water has increased and it is thought that bottled water is safer. But when exposed to sunlight or heat, it causes pollution in the water and the presence of heterotrophs and coliforms has been recorded in it [11][12]. Bottled water has the worst effect on the environment, the reverse osmosis system is more suitable for drinking and boiled water, although less expensive and easier to access, is suitable for non-drinking purposes [13]. Many people are unsatisfied with the supplied tap water so the point of Use (PoU) treated water has become popular. People choose their water filters from the publication of primary information sources through friends or salesman or own search on the internet about the water filter brand. Still, many are unaware of biofilms' formation in filters [14][15]. Over time, the deposition of organic solutes in the membrane causes the formation of biofilms in the filter and finally, the accumulation of particles on the surface of the membrane reduces the flow rate of water. Deposited membranes are not reusable and must be replaced [16]. So the use of (PoU) treated water System in the field of economy, health and environment are Expensive. This article aims to investigate the effect of RO water purifier on water quality, so the articles done in this field were reviewed.

2. Methods

2.1 Study protocol

This systematic review study investigated the effect of the reverse osmosis system on water quality by searching all articles published in Iranian journals and English-language journals. Inquired information was collected by searching for keywords on the Iranian and foreign databases. Iranian databases included: University Jihad Scientific Information Center (SID), Country Magazines Database (Magiran), Conference Proceedings (Sivilica) and Islamic World Articles Database (ISC). Foreign databases included: Pubmed, Scopus, ScienceDirect, Web of Science, Embase, Google Scholar, IEEE Xplore, Taylor and Francis, Emerald Insight and Wiley Online Library.

2.3 Search strategy

Inquired information was collected by searching for keywords on the listed sites, Key words included: ("Household water treatment systems" OR "point of Use" OR "POU" OR "reverse osmosis") AND ("Microbiological* and physicochemical* parameters" OR "Chemical parameters" OR " Physical parameters " OR "E.Coli" OR "Escherichia coli" OR "Coliform") AND ("tap water" OR " Inlet" OR " Outlet") AND (Iran). A manual search was performed by checking all published articles. The abstracts of all published articles were reviewed without a year limit. After finding the list of articles, books and dissertations related to the topic in case of incomplete study text, the author of the study was contacted via email and the desired information was obtained.

2.3.1 Inclusion criteria

Inclusion criteria for this study included: Type of point-of-use (POU) water treatment system (reverse osmosis), Inlet water source to the system (Urban tap water), Physicochemical and microbial parameters (Quantitative measurement of quality).

2.3.2 Exclusion criteria

Exclusion criteria for this study were: Lack of access to the full article in cases where it was not possible to contact the author of the study, inappropriate subject matter, Lack of sufficient information about the type of system, lack of information about the value of input and output parameters.

2.4 Quality assessment articles

This study is based on a standard checklist PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-analyzes). The US-based National Institute of Health Quality Assessment Tool for Observational Cohort and Cross-Sectional Studies for qualitative studies was used [17]. The checklist included 14 questions that were used for research purposes, samples, inclusion and exclusion criteria, findings, results and the publication period of each of the 19 articles (Table 1).

Table 1. Checklist of a quality assessment tool for observational cohort and cross-sectional studies [17]

Criteria	
1	Was the research question or objective in this paper clearly stated?
2	Was the study population clearly specified and defined?
3	Was the participation rate of eligible persons at least 50%?
4	Were all the subjects selected or recruited from the same or similar populations (including the same time period)? Were inclusion and exclusion criteria for being in the study prespecified and applied uniformly to all participants?
5	Was a sample size justification, power description, or variance and effect estimates provided?
6	For the analyses in this paper, were the exposure(s) of interest measured prior to the outcome(s) being measured?
7	Was the timeframe sufficient so that one could reasonably expect to see an association between exposure and outcome if it existed?
8	For exposures that can vary in amount or level, did the study examine different levels of the exposure as related to the outcome (e.g., categories of exposure, or exposure measured as continuous variable)?
9	Were the exposure measures (independent variables) clearly defined, valid, reliable, and implemented consistently across all study participants?
10	Was the exposure(s) assessed more than once over time?
11	Were the outcome measures (dependent variables) clearly defined, valid, reliable, and implemented consistently across all study participants?
12	Were the outcome assessors blinded to the exposure status of participants?
13	Was loss to follow-up after baseline 20% or less?
14	Were key potential confounding variables measured and adjusted statistically for their impact on the relationship between exposure(s) and outcome(s)?

2.5 Extract information from articles

In order to extract information, all articles were evaluated several times independently by two reviewers based on inclusion and exclusion criteria. Both reviewers eventually summarized the information and in cases where the information was inconsistent, a third reviewer's comments was used. The information extracted from the articles was included in the researcher's checklist for qualitative approval. The checklist included the name of the first author, the year of publication of the research and the order of the studies is based on the year of their publication (Table. 2).

Table 2. The information extracted from the articles

Rows	Author	Study Year	Release Year	City	Number of samples
1	Yari et al, [18]	2003	2008	Qom	100
2	Miranzadeh et al, [19]	2007	2010	Kashan	128
3	Jafaripour et al, [20]	2009	2011	Qom	NR
4	Rajaei et al, [21]	2011	2013	Arak	114
5	Tavangar et al, [22]	2012	2013	Bojnord	66
6	Sadig et al, [23]	2013	2015	Ardabil	24
7	Ebrahimi et al, [24]	2015	2015	Tabriz	36
8	Nourmoradi et al, [25]	2015	2017	Elam	100
9	Malakootian et al, [26]	2016	2017	Kerman	180
10	Rezaienia et al, [14]	2016	2018	Tehran	360
		2016	2018	Rasht	
		2016	2018	Ahvaz	
11	Talaeipour et al, [27]	2014	2018	Qom	NR
12	Naghipour et al, [28]	2017	2018	Rasht	64
13	Sobhani et al, [29]	2017	2018	Dashtestan	104
14	Bagapor et al, [30]	2018	2018	Shiraz	NR
15	Talebzadeh et al, [31]	2018	2018	Tabriz	60
16	Abolli et al, [32]	2018	2019	Garmsar	NR
17	Rezaienia et al, [33]	2019	2019	Tehran	200
18	Velayatzadeh et al, [34]	2019	2020	Ahvaz	48
19	Gholami-Borujeni et al, [35]	2020	2020	Sari	50

3. Findings

3.1 Search results

In this study, 544 article titles were found in the initial search with the keywords listed. In the first phase of the search process, 190 articles were identified. Then, 130 inappropriate and irrelevant articles were excluded for the study. Finally, after reviewing the information and quality of the articles, 19 articles were eligible for systematic review(Fig. 1).

Of the 19 articles reviewed, all of the articles were done in the last two decades. the most significant number of articles were published between 2012 and 2021. These studies were conducted more than once in Qom, Tabriz, Tehran and Ahvaz cities. In total, studies were conducted in 11 cities of Iran.

The qualitative results of the articles showed that most of the studies were of good quality. In the articles, the participation rate of eligible persons, inclusion and exclusion criteria, and exposure (s) were evaluated more than once but blinding of participant exposure status and potential confounding variables were not relevant and not applicable (Q3, Q12 and Q14) (Table 3).

3.2 Articles features

The research in this article was done by descriptive-analytical and descriptive-cross-sectional methods which Consider the effect of POU water treatment system on water quality. According to the book of Standard Methods for the Examination of Water and Wastewater [36], chemical and microbial tests were performed on water samples. Then, the results were compared with national and international standards [37] and international standards [38].

In the last two decades, many studies have been conducted on the quality of drinking water and how (POU) water treatment systems work. In 2003, Yari et al. Conducted the first study on RO in Iran [18]. Most research on water quality was conducted in different cities of Iran between 2009 and 2017.

In a 2019 study in Pasargad, it was found that two factors, total hardness (TH) and electrical conductivity (EC), had a greater impact on the quality of drinking water that the concentration of these parameters depends on the structure of geological formations in the region [39] [40]. Removal of heavy metals in city treatment plants requires special treatment processes [41]. Household water purifiers significantly affect the removal of heavy metals from water [34]. Farsi et al. Conducted a study in Ahvaz city water treatment plant which showed that the fluoride of Karun river water was reduced by water treatment process [42]. So The quality of output water depends on the source type and the incoming water quality parameters [39][43].

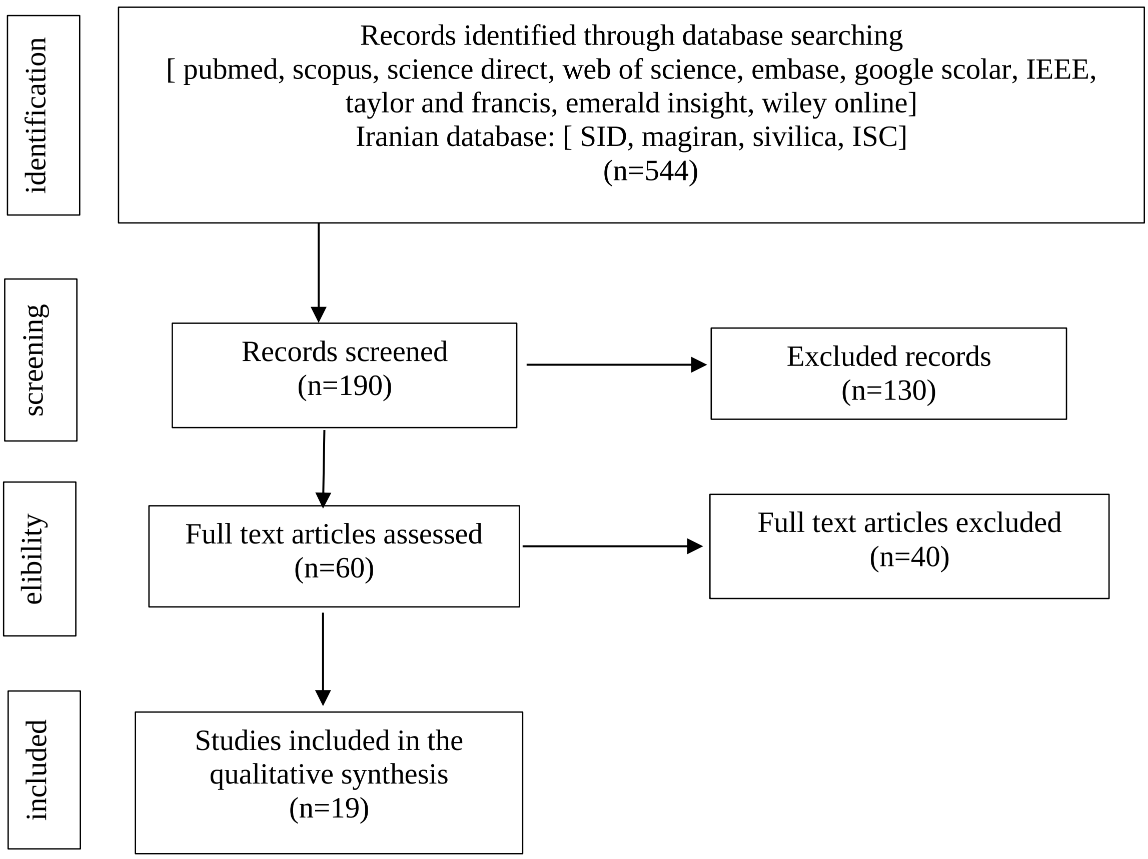

Figure 1. Flowchart describing the study design

Table 3. Quality of studies using the quality assessment of the NIH for cohort and cross-sectional studies

Author/ Year/ Ref	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14
Yari et al, 2003, [18]	✓	✓	NA	✓	✓	×	×	NA	✓	×	✓	×	×	NA
Miranzadeh et al, 2007, [19]	✓	✓	NA	✓	✓	×	×	NA	✓	✓	✓	×	×	NA
Jafaripour et al, 2009, [20]	✓	✓	NA	✓	✓	×	×	NA	✓	×	✓	×	×	NA
Rajaei et al, 2011, [21]	✓	✓	NA	✓	✓	×	×	NA	✓	✓	✓	×	×	NA
Tavangar et al, 2012, [22]	✓	✓	NA	✓	✓	×	×	NA	✓	✓	✓	×	×	NA
Sadig et al, 2013, [23]	✓	✓	NA	×	✓	×	×	NA	✓	NR	✓	×	×	NA
Ebrahimi et al, 2016, [24]	✓	✓	NA	×	✓	×	×	NA	✓	✓	✓	×	×	NA
Nourmoradi et al, 2016, [25]	✓	✓	NA	×	✓	×	×	NA	✓	×	✓	×	×	NA
Malakootian et al, 2016, [26]	✓	✓	NA	✓	✓	×	×	NA	✓	✓	✓	×	×	NA
Rezaeinia et al, 2016, [14]	✓	✓	NA	✓	✓	×	×	NA	✓	×	✓	×	×	NA
Talaeipour et al, 2014, [27]	✓	✓	NA	✓	✓	×	×	✓	✓	NR	✓	×	×	NA
Naghipour et al, 2017, [28]	✓	✓	NA	✓	✓	×	×	NA	✓	NR	✓	×	×	NA
Sobhani et al, 2017, [29]	✓	✓	NA	✓	✓	×	×	NA	✓	×	✓	×	×	NA
Baghapor et al, 2018, [30]	✓	✓	NA	✓	✓	×	×	NA	✓	NR	✓	×	×	NA
Talebzadeh et al, 2018, [31]	✓	✓	NA	×	✓	×	×	NA	✓	×	✓	×	×	NA
Abolli et al, 2018, [32]	✓	✓	NA	✓	✓	×	×	NA	✓	✓	✓	×	×	NA
Rezaienia et al, 2019, [33]	✓	✓	NA	✓	✓	×	×	NA	✓	×	✓	×	×	NA
Velayatzadeh et al, 2019, [34]	✓	✓	NA	✓	✓	×	×	NA	✓	×	✓	×	×	NA
Gholami et al, 2020, [35]	✓	✓	NA	✓	✓	×	×	NA	✓	×	✓	×	×	NA

Cases that were followed in the articles were marked (✓) and those that were not followed were marked (×). Items that were not executable were also identified by the word (NA) not applicable and (NR) not reported.

4. Discussion

Iran has historically faced water shortages. The demand for safe drinking water has increased [44]. For this reason, the use of drinking water in Iran is often through domestic) water treatment or through mobile purifiers throughout the city [22]. Studies on water purification by POU in

Iranian cities were reviewed, the amount of parameters measured is shown in (Table 4). According to (Fig.2) the amount of fecal coliform and total coliform at the input and output of the RO device were almost equal. Research has shown that coliforms grow due to the lack of chlorine in the effluent. Because the pre-treatment system removes chlorine, but the time to replace the membrane and pre-treatment filters was not specified [45].

This could be another reason for the presence of coliforms in the effluent because if RO membranes are biologically fouling, a suitable environment is created for the growth of coliforms. Failure to check the membranes at the appropriate time and regularly check the chemical and physical parameters at the input and output can be another reason for the presence of coliforms [6]. A large increase in heterotrophic bacteria at the system's output can also be due to this. But in the studies, no attention was paid to the water storage tank after the system, This tank is often a good place for bacteria to grow because it is not washable [46]. A study by Ayden in 2018 in Turkey showed that the amount of Escherichia coli bacteria was found in 5 of the input samples, but this amount increased to 29 in the output samples [47]. The function of the membranes of the water treatment device RO filter is to remove the TDS; If it is not well pre-treated, it will cause fouling, scaling and biological fouling in the membranes [48]. In some cities, tap water is very hard, such as Gorgan [49], Qom and Dashtestan, So here it is important to have pre-treatment before RO which is not discussed in these articles but usually, three pre-treatment filters such as fiber, activated carbon and carbon black are used in home water treatment systems, Each of which can delete different parameters [6] But the task of removing TDS is the responsibility of RO [48]. According to (Fig.3), RO was able to eliminate TDS well. At the output; fluoride became much lower than standard (Fig.3). A study in Finland on the effect of POU on fluoride concentration in water found that 91.75% of fluoride removal occurred by POU system [50]. Fluoride is essential in the growth and strength of teeth and bones, especially among children, and the most appropriate way to receive this ion is by drinking water [51]. In a study in Qeshm, at the systems' output, all parameters were standard except for the total hardness and fluorine, which were lower than the standard limit [52].

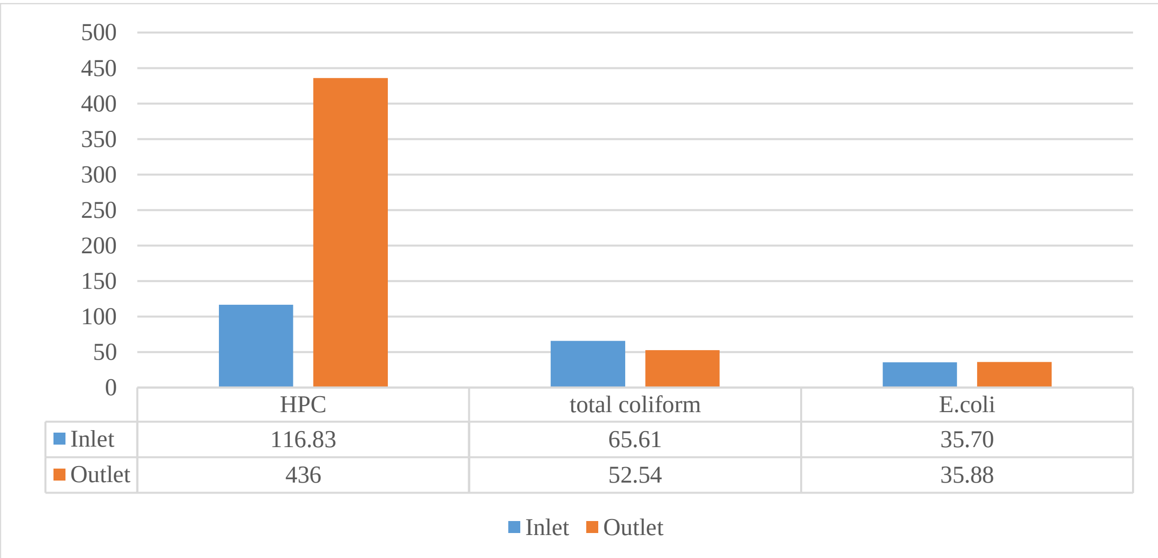

Figure 2. Average microbial parameters in all of Iran

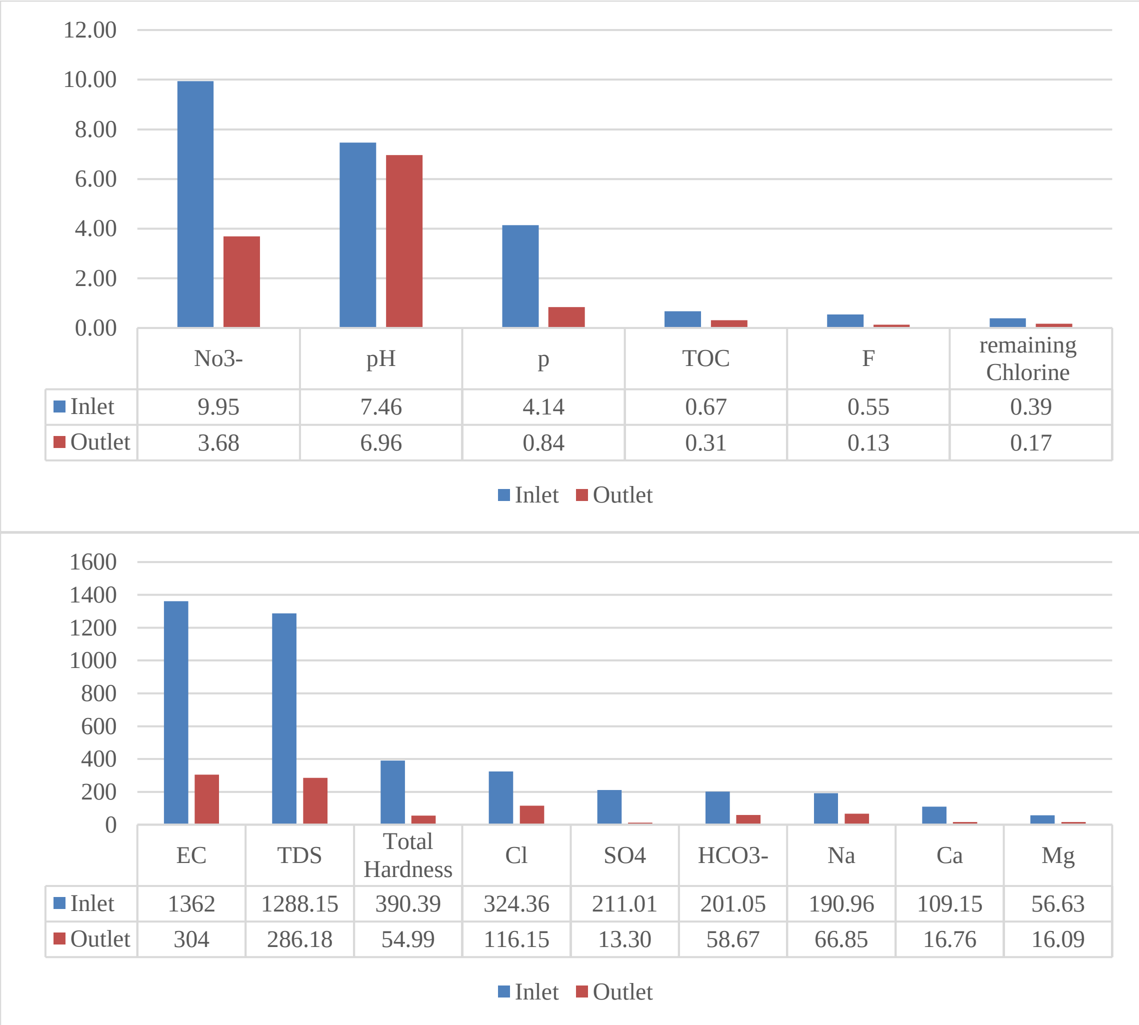

Figure 3. Average chemical parameters in all of Iran

5. Conclusion

This study aimed to investigate the effect of POU system on drinking water quality in different cities of Iran. Depending on the geographical area of each city, the amount of chemical, physical and microbial parameters in each city was different. The measured parameters in the tap water were standard in some cities and there was no need to use POU. In some cities, EC, TDS and total hardness were high, which reached the desired standard after leaving the POU machine. But since the POU system reduces all parameters and is not selective, it greatly reduces the amount of chlorine, fluorine and sometimes TDS. As the TDS decreases, the pH decreases and the water may become acidic. As chlorine decreases, the amount of microbial contamination in the effluent increases. By reducing the fluoride in the effluent, the health of the teeth and bones is compromised over time. Therefore, it should give the necessary training in water health and diseases resulting from it to consumers and operators of these systems and all filters should be changed on time, otherwise the quality decrease of POU outpot occurs.

Table 4. The amount of input and output parameters of the POU system in Iranian cities

Author/Year/Ref	Parameter	Inlet	Outlet	standards values determined by Iran and the WHO	
				iran	WHO guideline
Yari et al, 2003, [18]	Chlorine(Cl)	572.3	71.06	250 - 400	250
	Total Hardness	651.3	45.71	200 - 500	300
	pH	7.43	6.35	6.5 - 9	6.5 - 8.5
	EC	2651.4	275.78	500 - 1500	1500
	Fluorine (F)	1.3	0.3	0.5 – 1.5	1.5
	remaining Chlorine	-	0.28	5	5
	Alkalinity	223	31.04	-	-
	Mg2+	88.27	7.6	30	-
	Calcium (Ca2+)	118.05	7.93	300	200
	TDS	1872.46	165.46	1000 - 1500	600 - 1000
	Turbidity	0	0.04	1 - 5	1 - 4
	Hardness (as Mg2+)	362.89	31.3	200 - 500	300
	Iron (Fe)	0.02	0.01	_0.3	0.3
Miranzadeh et al, 2007, [19]	TDS	852.4	245.18	1000 - 1500	600 - 1000
	Total Hardness	319.37	118.25	200 - 500	300
	Hardness (as Ca2+)	197	71.5	-	-
	Hardness (as Mg2+)	122.62	46.97	-	-
	potassium (K)	8.6	1.82	-	-
	Fluorine (F)	0.83	0.2	0.5 – 1.5	1.5
	Chlorine(Cl)	204.81	68.5	250 - 400	250
	Sulfate (So4)	176.09	24.31	250 - 400	250
	Nitrate (No3-)	9.12	2.46	50	50
	Sodium (Na)	134.06	37.28	200	200
	pH	7.08	6.84	6.5 - 9	6.5 - 8.5
Jafaripour et al, 2009, [20]	TDS	1945	235	1000 - 1500	600 - 1000
	pH	6.7	7.2	6.5 - 9	6.5 - 8.5
	Total Hardness	1018	40	200 - 500	300
	Chlorine(Cl)	520	115	250 - 400	250
	Nitrate (No3-)	7.3	3.33	50	50
	Nitrite (No2-)	0.0075	0.0013	3	3
	Magnesium (Mg2+)	125	5.82	30	-
	Iron (Fe)	0.16	0.28	0.3	0.3
	Manganese (Mn)	0.92	0.35	0.1 – 0.4	0.4

Author/Year/Ref	Parameter	Inlet	Outlet	standards values determined by Iran and the WHO	
				iran	WHO guideline
	Fluorine (F)	0.92	0.35	0.5 – 1.5	1.5
	Calcium (Ca2+)	199.5	7	300	200
	Sulfate (So4)	950	30	250 - 400	250
Rajaei et al, 2011, [21]	Sulfate (So4)	68.02	3.83	250 - 400	250
	Nitrate (No3-)	35.58	14.88	50	50
	Nitrite (No2-)	0.002	0.006	3	3
	Bicarbonate (HCO3-)	231.58	84.94		
	Chlorine(Cl)	114.31	19.76	250 - 400	250
	Calcium (Ca2+)	108.98	17.92	300	200
	Magnesium (Mg2+)	34.82	8.05	30	-
Tavangar et al, 2012, [22]	Turbidity	0.91	0.42	1 - 5	1 - 4
	pH	8.21	7.68	6.5 - 9	6.5 - 8.5
	remaining Chlorine	0.89	0.64	5	5
	Alkalinity	291.52	78.24		
	Heterotrophic bacteria (HPC)	80.51	177.4	< 500	< 500
	Total coliforms	2	5.6	0	0
	Escherichia coliform (E.coli)	1.1	1.1	0	0
	Clostridium perfringens bactria	279.13	570.18	0	0
Sadig et al, 2013, [23]	Sulfate (So4)	68.02	3.83	250 - 400	250
	Nitrate (No3-)	6.1	0.93	50	50
	Nitrite (No2-)	0.22	0.24	3	3
	Fluorine (F)	0.6	0.16	0.5 – 1.5	1.5
	Chlorine(Cl)	96.23	13.06	250 - 400	250
	Total Hardness	277.55	37.33	200 - 500	300
	Hardness (as Ca2+)	200.22	16.88	-	-
	Hardness (as Mg2+)	70	20.66	-	-
	Sodium (Na)	173.38	10.82	200	200
	Phosphate (PO4 3-)	19.07	4.22		
	EC	875.84	83.03	500 - 1500	1500
	TDS	576.45	53.19	1000 - 1500	600 - 1000
	Turbidity	0.46	0.17	1 - 5	1 - 4
	pH	8	7.21	6.5 - 9	6.5 - 8.5
Ebrahimi et al, 2016, [24]	pH	7.4	6.88	6.5 - 9	6.5 - 8.5
	Temperayure (T)	14.61	16.7		
	remaining Chlorine	0.48	0	5	5

Author/Year/Ref	Parameter	Inlet	Outlet	standards values determined by Iran and the WHO	
				iran	WHO guideline
	Escherichia coliform (E.coli)	1	1	0	0
Nourmoradi et al, 2016, [25]	EC	592.63	175.98	500 - 1500	1500
	TDS	324.27	95.88	1000 - 1500	600 - 1000
	Turbidity	1.63	0.63	1 - 5	1 - 4
	pH	7.8	7	6.5 - 9	6.5 - 8.5
	remaining Chlorine	0.05	0	5	5
	Heterotrophic bacteria (HPC)	585.6	593.6	< 500	< 500
	Total coliforms	259.82	203.66	0	0
	Escherichia coliform (E.coli)	176.22	177.08	0	0
Malakootian et al, 2016, [26]	Chlorine(Cl)	80.47	30.6	250 - 400	250
	Nitrite (No2-)	0.01	0.017	3	3
	Nitrate (No3-)	1.38	0.54	50	50
	Sulfate (So4)	61.19	9.92	250 - 400	250
	Bicarbonate (HCO3-)	188.8	54.23		
	Magnesium (Mg2+)	69.4	48.63	30	-
	Calcium (Ca2+)	132.46	48.63	300	200
	Sodium (Na)	87.8	18.9	200	200
	Total Hardness	260.2	97.24	200 - 500	300
Rezaeinia et al, 2016, [14]	pH	7.68	7.2	6.5 - 9	6.5 - 8.5
	EC	493	49.8	500 - 1500	1500
	Total Hardness (CaCO3)	164.4	33	200 - 500	200 - 300
	Nitrate (No3-)	13.75	4.5	50	50
	Fluorine (F)	0.33	0.02	0.5 – 1.5	1.5
	Total organic carbon (TOC)	0.22	0.05		
	Heterotrophic bacteria (HPC)	3	543	< 500	< 500
Rezaeinia et al, 2016, [14]	pH	6.77	6.05	6.5 - 9	6.5 - 8.5
	EC	455	49.8	500 - 1500	1500
	Total Hardness (CaCO3)	245.7	34.5	200 - 500	200 - 300
	Nitrate (No3-)	4.66	0.98	50	50
	Fluorine (F)	0.29	0.01	0.5 – 1.5	1.5
	Total organic carbon (TOC)	0.11	0.06		
	Heterotrophic bacteria (HPC)	2	554	< 500	< 500
Rezaeinia et al, 2016, [14]	pH	7.27	6.7	6.5 - 9	6.5 - 8.5
	EC	1437	58.17	500 - 1500	1500

Author/Year/Ref	Parameter	Inlet	Outlet	standards values determined by Iran and the WHO	
				iran	WHO guideline
	Total Hardness (CaCO3)	217.5	41.5	200 - 500	200 - 300
	Nitrate (No3-)	1.7	0.52	50	10
	Fluorine (F)	0.5	0.23	0.5 – 1.5	1.5
	Total organic carbon (TOC)	1.69	0.83		
	Heterotrophic bacteria (HPC)	43	676	< 500	< 500
Talaeipour et al, 2014, [27]	Salinity (%)	2.43	0.68		
	TDS	3000.9	1192.5	1000 - 1500	600 - 1000
	EC	4771.3	1892.8	500 - 1500	1500
	Chlorine(Cl)	1223.4	696.4	250 - 400	250
	Sodium (Na)	686.4	312.9	200	200
Naghipour et al, 2017, [28]	Turbidity	0.73	0.26	1 - 5	1 - 4
	Temperayure (T)	23.1	23.9		
	pH	7.62	6.95	6.5 - 9	6.5 - 8.5
	EC	587	124	500 - 1500	1500
	Total Hardness (CaCO3)	182.5	56.4	200 - 500	200 - 300
	Total Alkalinity (CaCO3)	190.1	53.7		
	Total coliforms	0.4	0.9	0	0
	Escherichia coliform (E.coli)	0	0.2	0	0
	Heterotrophic bacteria (HPC)	7	324	< 500	< 500
	remaining Chlorine	0.2	0	5	5
	Manganese (Mn)	0.07	0.0025	0.1 – 0.4	0.4
	Calcium (Ca2+)	47.9	14.1	300	200
	Magnesium (Mg2+)	14.1	6.9	30	-
	Sodium (Na)	31.7	11.2	200	200
	potassium (K)	0.51	0.1		
	Iron (Fe)	0.13	0.05		
	Nitrate (No3-)	1.1	0.69	50	50
	Chlorine(Cl)	63.7	22.7	250 - 400	250
	Fluorine (F)	0.03	0.02	0.5 – 1.5	1.5
	Bicarbonate (HCO3-)	230.8	65.5		
Sobhani et al, 2017, [29]	TDS	777	119.5	1000 - 1500	600 - 1000
	Total Hardness	771.75	78	200 - 500	300
	Fluorine (F)	0.635	0.05	0.5 – 1.5	1.5
	Nitrate (No3-)	8.99	2.04	50	50

Author/Year/Ref	Parameter	Inlet	Outlet	standards values determined by Iran and the WHO	
				iran	WHO guideline
	remaining Chlorine	0.6	0.2	5	5
	pH	7.4	6.8	6.5 - 9	6.5 - 8.5
Baghapor et al, 2018, [30]	Sulfate (So4)	95.76	17.2	250 - 400	250
	Nitrate (No3-)	17.26	9.34	50	10
	remaining Chlorine	0.4	0	5	5
Talebzadeh et al, 2018, [31]	remaining Chlorine	0.2	0	5	5
	pH	7.4	6.97	6.5 - 9	6.5 - 8.5
	EC	464.7	69	500 - 1500	1500
	Turbidity	0.8	0.45	1 - 5	1 - 4
	Total Hardness (CaCO3)	186	23	200 - 500	200 - 300
	Calcium (Ca2+)	48	5	300	200
	Magnesium (Mg2+)	18	3	30	-
	Sodium (Na)	32.4	10	200	200
	potassium (K)	3.3	0.6		
	Alkalinity (HCO3-)	126	24		
	Bicarbonate (HCO3-)	153	30		
	Sulfate (So4)	58	4	250 - 400	250
	Chlorine(Cl)	44	8.3	250 - 400	250
	Nitrate (No3-)	12.4	4	50	50
	Nitrite (No2-)	0	0	3	3
	Iron (Fe)	0.13	0.04	0.3	0.3
	Zinc (Zn)	0.53	0.03	3	3
	Copper (Cu)	0.012	0.0057	1	
Abolli et al, 2018, [32]	Fluorine (F)	0.061	0.004	0.5 – 1.5	1.5
	EC	1822.6	384.4	500 - 1500	1500
	TDS	956.7	182.7	1000 - 1500	600 - 1000
	pH	7.94	7.9	6.5 - 9	6.5 - 8.5
	remaining Chlorine	0.7	0.54	5	5
	Heterotrophic bacteria (HPC)	96.7	184.6	< 500	< 500
	Total coliforms	0.207	0	0	0
	Escherichia coliform (E.coli)	0.187	0	0	0
Rezaienia et al, 2019, [33]	Chromium (Cr)	0.006	0.001	0.05	
	Copper (Cu)	0.012	0.007	1 - 2	
	Iron (Fe)	0.021	0.008	0.3	0.3

Author/Year/Ref	Parameter	Inlet	Outlet	standards values determined by Iran and the WHO	
				iran	WHO guideline
	Zinc (Zn)	0.291	0.136	3	3
	Nickel (Ni)	0.002	0.001	0.07	
	Manganese (Mn)	0.001	0.0007	0.1 – 0.4	
Velayatzadeh et al, 2019, [34]	Calcium (Ca2+)	144.79	25.8	300	200
	Potassium (K)	4.35	2.22	-	-
	Magnesium (Mg2+)	26.5	5.57	30	-
	Sodium (Na)	143.16	43.61	200	200
	Zinc (Zn)	0.3	0.13	3	3
	Iron (Fe)	0.108	0.051	0.3	0.3
	Manganese (Mn)	0.042	0.01	0.1 – 0.4	-
	Copper (Cu)	0.081	0.027	1 - 2	-
	Cobalt (Co)	0.003	0.002	-	-
	Chromium (Cr)	0.003	0.002	0.05	-
Gholami et al, 2020, [35]	EC	832	186	500 - 1500	1500
	Turbidity	0.65	0.1	1 - 5	1 - 4
	pH	7.22	6.63	6.5 - 9	6.5 - 8.5
	remaining Chlorine	0.41	0	5	5

All parameters measuring unit was mg/l: except pH (no unite); Turbidity (NTU); EC (µmohs/cm); Heterotrophic bacteria (CFU/ml); Total coliforms and E.coli (MPN/100cc)

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