زانكۆی سەلاحەددین-هەولێر

Salahaddin University-Erbil

Physicochemical quality evaluation of water taken from home filtration systems in Erbil, Kurdistan Region of Iraq.

Research project

Submitted to the department of biology in partial fulfillment of the requirements for the degree of B.Sc. in Biology.

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Supervised by: **Abdullah H. Aziz**

Aprin-2024

SUPERVISOR CERTIFICATE

This research project has been written under my supervision and has been submitted to the department of biology for the award of the degree of B.A. in biology with my approval as supervisor.

Signature:

Name: **Dr. *Abdulla H. Aziz***

Date: **April 1, 2024**

I confirm that all requirements have been fulfilled.

Signature:

Name: **Assist. Prof. Dr. Sevan O. Majeed**

Head of the Department of biology

Date: **April 1, 2024**

Dedication

I dedicate this work to

My parents …

Sumaya

Acknowledgements

In the name of Allah. Thanks to Allah for directing me and assisting me in completing my research project. He has been a source of comfort and support for me throughout my academic career.

I am really grateful to Salahuddin University-Erbil for providing me the chance to finish my study. A particular thank you goes out to the dean of the college of education and the head and staff of the biology department.

My family deserves a particular thank you for supporting me throughout my whole academic career and enabling me to pursue a university education.

My sincere appreciation to my supervisor, Dr. Abdulla Hamad Aziz for his unfailing support and direction.

The rest of my family members for their encouragements, love, care and support.

Summary

A laboratory study was carried out to determine the best performance of domestic water filter available in Erbil city, Kurdistan Region of Iraq. Water samples were collected in inlet and outlet of each type of filter. The samples were analyzed for Hydrogen ion concentration pH, Electrical Conductivity-EC, Total Dissolved Solid-TDS, Total Alkalinity, Total Acidity, Total Hardness, Chloride-Cl^-, Nitrite-NO_2, Nitrate-NO_3 and Phsphate-PO_4.

The pH value of the inlet (freshwater tank) ranged between 6.56 recorded at Kurdistan inlet and 8.4 recorded at Bnaslawa outlet. The pH of the water after passing water filters showed low percent of reduction and ranged between 0.13% and 15.14%. The EC of the inlet water ranged between 9 and 1055 μS cm^{-1}. Generally, all types of home water filters showed high performance in EC percent reduction with mean value of 82%. Total Dissolved solids levels ranged between 7 and 527 mg 1^{-1}. The minimum value was recorded at Kurdistan outlet, while the highest value was measured at Mala Qara inlet. The highest percent of reduction of 96.88% was detected at 99 Zanko and the lowest value of 18.75% was measured at 55 Quarter. Generally, all types of home water filters showed high performance in TDS percent reduction with mean value of 85%. Chloride values ranged between 3.97 and 73.45 mg l^{-1}. The lowest level was recorded at Andaza outlet, whereas the highest concentration was measured at Mala Qara inlet during January 2024. The chloride removal efficiency ranged between 0% recorded at Bahari New, Mnara and Kurdistan to 91.98% measured at Mala Qara.

The Total Alkalinity value ranged between 8 and 188 mg $CaCO_3$ l^{-1}. The minimum value recorded at Bnaslawa outlet while the maximum value was measured at Turaq inlet. The Total Hardness value ranged between 12 and 166 mg $CaCO_3$ 1^{-1}. The highest percent of reduction of 92.41% was detected at Bahari New site and the lowest value of 4.76% was measured at Kurdistan site. The Nitrate NO_2 value (Table 1 and 2, Figure 8) of the inlet water and outlet water of the filters were same and ranged between 0.33 and 0.41 mg l^{-1}. The Nitrate NO_3 value of the inlet water ranged between 0.33 mg I^{-1} recorded at Bnaslawa outlet and 2.59 mg I^{-1} recorded at 99 Zanko inlet. The highest percent of reduction of 86.43% was detected at Bahari New site and the lowest value of 1.09% was measured at Nawroz site. The phosphate PO_4 level (Table 1 and 2, Figure 10) are similar in both inlet and outlet of the studied filters, i.e the performance of filters to remove the phosphate from water was very low and never exceed 55.6%.

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Chapter One

1.Introduction

An increase in the global human population has resulted in a corresponding growth in safe drinking water demand. To maintain and sustain life, there is a need for the provision of safe drinking water. However, current figures indicate that about 1/7th (1 billion) of the world population do not have access to improved drinking water supplies, mainly in developing countries (Kim *et al*., 2013) (Jonah and Elefsiniotis, 1996). This condition forces communities, especially those living in rural areas, to consume any available water source from rivers, dams or ponds without prior treatment. According to epidemiological studies, the consumption of contaminated drinking water has been associated with waterborne outbreaks of diseases such as gastroenteritis, hepatitis A, hepatitis E, etc. which are of parasitic and viral origin. Waterborne pathogens contribute to an estimated 4 billion cases and 2.5 million deaths from diarrheal diseases each year (Jonah and Elefsiniotis, 1996).

Erbil city supplied by freshwater from both surface and groundwater through Efraz Treatment plants on Greater Zab River and wells respectively. The quality of freshwater supply (quantity and types of salts), and contribution of pollutants the surrounding environment may contaminate freshwater stored in tanks. Therefore, this water should be treated before it used for drinking purposes, and different types of water filters are used for this purpose. Commercial water filters are used in the private houses and government buildings. The treatment includes removal of suspended solids, organic matter, microorganisms including bacteria, fungi and algae as well as reduction of salinity of water. The suspended solids can be removed using the ceramic filters, sand filters and five micron cartridge filters. The organic matters and materials causing bad smell, and color of water in the storage tank can be removed using activated carbon filters and sand filters. The microorganisms including bacteria can be removed by sterilizing the water using ultraviolet (UV) filters. The reduction of salts of fresh water is generally carried out using reverse osmosis through membrane filters. The selection of type of filters to be used depends on the capital and operation costs, the removal efficiency of pollutants from the freshwater, and the quantity of produced treated water.

Bottled water comes from a variety of sources, like spring and mineral water drawn from underground; they differ in their composition and mineral content (Warburton and Austin, 2000). Environmental pollution is one of the most horrible crises that we are facing today. Due to the increased urbanization and industrialization. Surface water pollution has become a crucial problem. It is necessary to have precise and appropriate information to observe the quality of any water resources and to develop some useful tools for monitoring the quality of such free resources to retain their excellent quality for various beneficial uses (Alam and Pathick, 2010). The need for research on the quality of bottled water is crucial. And, there is very limited information on bottled drinking water quality that comes from the ground and surface water. Thus, there is an urgent need to evaluate and classify the commercially available bottled waters concerning the Standards to safeguard the health and safety of the consumers. Furthermore, the mineral content of bottled water is one of the most important indicators of water quality.

The aims of the study are:

1. The groundwater and surface water quality (inlet of water filters) in different sites within Erbil city through analyses of physical and chemical parameters important in water quality decision.

2. The efficiency of drinking water filters (% of Reduction) in improvement of water quality through inlet and outlet analysis of different filters.

3. Comparison between different drinking water filters from home filtration systems in Erbil city.

Chapter Two

2. Literature Review

Many Studies around the world has been done to assess the efficiency and comparison between different home water treatment systems. Adeyemo *et al*., 2015 conducted a laboratory study of the use of carbon filters in drinking water filters for removal of trace metals. The results indicated that a binary mixture of carbons from acid activated were the most effective in removing these metals from drinking water of all systems evaluated. Al-Haddad *et al*., 2015 conducted a laboratory study of point of use household drinking water filtration. They observed that the lack of safe water creates a tremendous burden of diarrheal disease, life-threatening illnesses for people in the developing world. Ceramic and biosand household water filters are identified as most effective according to the evaluation criteria applied and as having the greatest potential to become widely used and sustainable for improving household water quality to reduce waterborne disease and death. Bolaji *et al*., 2023 conducted a laboratory study of Performance evaluation of a locally developed domestic drinking water filter they observed comparison of results obtained with the WHO standards for drinking water showed that the filter can provide portable drinking water of the required standard. The filter average removal efficiency of turbidity, hardness, conductivity, total dissolved solid (TDS) and total suspended solid (TSS) from water samples were 95.1, 70.3, 73.1, 69.4 and 98.7%, respectively.

Birhane *et al*., 2014 evaluates the performance of a polymeric microfiltration membrane, as well as its combination with a coconut granular activated carbon pretreatment, in a gravitational filtration module, to improve the quality of water destined to human consumption. The obtained results for filtrations with and without granular activated carbon pretreatment were similar in terms of water quality; while it was ensured higher chlorine removals, as well as higher initial permeate fluxes.

Tahir, 2022 compared the effectiveness and sustainability of five selected cost-effective home water treatment systems in removing Cryptosporidium and Giardia spp. from water sources. The results revealed that the average turbidity of the intake water samples ranged between 1.47 and 42.93 NTU before filtration and between 0.05 and 14.49 NTU after filtration. Misra *et al*., 2015conducted a laboratory study of Efficiency of locally available filter media on fluoride and phosphate removal for household water treatment system. Laboratory analysis was carried out before and after filtration to determine the removal efficiency of each medium.

Silva *et al*., 2012conducted a laboratory study of effectiveness of domestic water filters. The results indicated that inlet water had low salinity (TDS value 275-438 mg/l), low TSS (0-7 mg/l), chlorine (0.13–0.78 mg/l) and high content of bacteria (1-1212 MPN/100 ml). The authors revealed that the membrane of the RO combined filter set was exposed to severe damage by the residual chlorine in the water, rendering the membrane unable to reduce water salinity effectively and causing high total bacteria counts in the filtered water. Additionally, a biological slime layer formed at the surfaces of cartridge filters, and produced high values of TSS and bacteria in the filtrate samples. The results showed that the best type of filter was the five micron filter on the basis of cost, volume of filtered water, and improvement in water quality. Kim *et al*., 2013studied the devices which were consisted of four units; primary filter, carbon filter, Reverse Osmosis membrane, and storage tank. Analysis showed that Point-of-Use Drinking Water Treatment Units POU-DWTUS were able to reduce the dissolved solids content more than 90% and produced soft water. However the amount of heavy metals removed are not successful and reliable in the complete removal of heavy metals.

Chapter Three

3. Materials and Methods:

3.1. Physical analysis:

3.1.1. Hydrogen ion concentration (pH):

It was measured directly in the field by Electrometric method using a portable pH-meter model (HANNA instrument, Portugal). The instrument was calibrated before each sampling using buffer solutions of (pH=4, 7and9) as described by A.P.H.A. (2012).

3.1.2. Electrical Conductivity (EC):

It was measured in the field using a portable conductivity meter model (HI 9811, HANNA instruments, 2000) calibrated with (0.01M) potassium chloride solution before each sampling, the results were expressed in $\mu S.cm^{-1}$ as described by (A.P.H.A., 2012).

3.1.3. Total Dissolved Solids (TDS):

Measured in the field using a portable TDS-meter model (HI9811, HANNA instruments, 2000), the results were expressed in mg l^{-1}. (A.P.H.A., 2012).

3.2. Chemical analysis:

3.2.1. Total Alkalinity:

It was determined in the laboratory by Titration method recommended by A.P.H.A. (2012), the results were expressed in mg $CaCO_3$ l^{-1} using the formula bellow:

AlkalinityasmgCaCO$_3$ l^{-1} =A*B*50000/ml of sample.

Where: A= ml of standard acid titrant. B= normality of standard acid.

3.2.2. Total Acidity:

Acidity was determined by titration method as described by A.P.H.A. (2012), the results were expressed in mg $CaCO_3$ l^{-1} using the following formula:

AcidityasmgCaCO$_3$ l^{-1} =A*B*50000/ml of sample.

Where: A=ml of standard NaOH titrant used. B= normality of standard NaOH.

3.2.3. Total Hardness:

It was determined by EDTA titrimetric method as described by A.P.H.A. (2012), using Erichrom Black T as indicator and buffer solution of pH 10, the results were expressed in mg$CaCO_3$ l^{-1} using the formula bellow: Hardnessasmg$CaCO_3$ l^{-1} =A*B*1000/ml of sample.

Where: A=ml titration for sample. B=mg$CaCO_3$equivalentto 1mlEDTAtitrant.

3.2.4. Chloride (Cl^-):

It was determined by Argentometric method using silver nitrate titrantas described by A.P.H.A. (2012), the results were expressed in mg Cl^- l^{-1} by equation: mg Cl^- l^{-1}=(A-B)*N*35450/ml of sample.

Where: A= ml titration for sample. B= ml titration for blank.

N=normalityof$AgNO_3$.

3.2.5. Nitrite (NO_2):

Determined by Spectrophotometric method according to Beendischnider and Robinson (1952) as described by Parsons *et. al* (1984) using wavelength of 543nm in 1cm cauvatt cell using spectrophotometer model (PYEUNICAM SP 6.550, England), the results were expressed in µg-atN-N.

3.2.6. Nitrite (NO_2):

Determined by Spectrophotometric method according to Beendischnider and Robinson (1952) as described by Parsons, *et. al* (1984) using wavelength of 543nm in 1cm cauvatt cell using spectrophotometer model (PYEUNICAM SP 6.550, England), the results were expressed in µg-atN-$NO_2$$l^{-1}$.

3.2.7. Reactive Phosphorus (PO4-3):

The procedure used (Ascorbic acid reduction method) was that of Murphy and Riley (1962), as described by Parsons *et. al* (1984). The absorbance was measured in 1cm cauvatt cell at the wavelength 885nm, the results were expressed in µg-atP-$PO_4$$l^{-1}$.

Chapter Four

4.Results and discussion

The samples were collected from fifteen various locations in Erbil City. At each site, two samples were taken, one from the inlet and the second from the outlet of home drinking water filtration system. The collected samples were analyzed for major physical and chemical water quality parameters like pH, Electrical Conductivity-EC, Total Dissolved Solid-TDS, Total Alkalinity, Total Acidity, Total Hardness, Chloride-Cl^-, Nitrite-NO_2, Nitrate-NO_3 and Phsphate-PO_4.

The change in the quality of freshwater after passing through eight house water filters was evaluated. The water samples were analyzed for water quality parameters before and after passing each type of water filters. The effect of different types of water filters on the physical and chemical parameters was evaluated separately (Table 1).

The pH value (Table 1 and 2, Figure 1) of the inlet (freshwater tank) ranged between 6.56 recorded at Kurdistan inlet and 8.4 recorded at Bnaslawa outlet. The pH of the water after passing water filters showed low percent of reduction and ranged between 0.13% and 15.14%. We can conclude that home water filters not affect the change of water pH as stated by Al-Haddad *et al*. 2015.

The EC (Table 1 and 2, Figure 2) of the inlet water ranged between 9 and 1055 $\mu S\ cm^{-1}$. The minimum value was recorded at Bnaslawa outlet, while the highest value was measured at Mala Qara outlet. The highest percent of reduction of 98.32% was detected at Bnaslawa and the lowest value of 20.45% was measured at Dream City. Generally, all types of home water filters showed high performance in EC percent reduction with mean value of 82%. Same results were concluded by Silva *et al*., 2012, Fahiminia *et al*., 2014 and Al-Haddad *et al*. 2015.

Total Dissolved solids TDS (Table 1 and 2, Figure 3) levels ranged between 7 and 527 mg 1^{-1}. The minimum value was recorded at Kurdistan outlet, while the highest value was measured at Mala Qara inlet. The highest percent of reduction of 96.88% was detected at 99 Zanko and the lowest value of 18.75% was measured at 55 Quarter. Generally, all types of home water filters showed high performance in TDS percent reduction with mean value of 85%. Same results were concluded by Silva *et al*., 2012, Fahiminia *et al*., 2014 and Al-Haddad *et al*. 2015.

Table 1: Physico-chemical components of Thirty tap and filtered water samples in Erbil city. Jan. 2024.

Brands	**pH**	**EC µS cm^{-1}**	**TDS mg/l**	**Cl^- mg/l**	**Alk. mg/l**	**Acid. mg/l**	**Hard. mg/l**	**NO_2 mg/l**	**NO_3 mg/l**	**PO_4 mg/l**
32 Park, Inlet	7.88	611.0	305.0	23.822	102.0	12.0	136.0	0.362	1.809	0.770
32 Park, Outlet	7.36	42.0	21.0	13.896	15.0	4.0	16.0	0.357	0.742	0.420
55 Q., Inlet	7.51	553.0	224.0	19.852	132.0	24.0	**166.0**	**0.412**	2.506	0.780
55 Q., Outlet	7.50	365.0	182.0	13.896	90.0	16.0	150.0	0.388	1.924	0.745
99 Zanko, Inlet	7.67	449.0	224.0	15.882	124.0	8.0	126.0	0.388	**2.59**	0.920
99 Zanko, Outlet	7.20	14.0	7.00	11.911	50.0	4.0	12.0	0.336	0.580	0.770
Andaza, Inlet	7.96	443.0	221.0	27.793	110.0	18.0	122.0	0.388	1.590	0.720
Andaza, Outlet	7.76	53.0	27.0	**3.970**	16.0	6.0	24.0	0.359	0.445	0.495
Bahari New, Inlet	7.80	713.0	356.0	45.660	124.0	10.0	158.0	0.349	2.428	0.695
Bahari New, Outlet	6.83	25.0	13.0	45.660	10.0	4.0	12.0	0.346	0.330	0.595
Bnaslawa, Inlet	7.73	537.0	268.0	17.867	94.0	12.0	140.0	0.375	2.013	1.170
Bnaslawa, Outlet	**6.56**	**9.00**	19.0	5.956	**8.0**	6.0	14.0	0.340	**0.33**	0.770
Deiy Zanko, Inlet	7.83	420.0	208.0	15.882	102.0	8.0	16.0	0.372	1.720	0.945
Deiy Zanko, Outlet	6.96	35.0	17.0	5.956	10.0	6.0	30.0	0.359	0.535	**0.420**
Dream City, Inlet	7.74	44.0	240.0	13.896	134.0	14.0	128.0	0.346	1.638	0.670
Dream City, Outlet	6.93	35.0	17.0	5.956	10.0	6.0	18.0	0.349	0.829	0.520
Kwestan, Inlet	7.25	465.0	233.0	11.911	84.0	**26.0**	134.0	0.378	1.209	1.495
Kwestan, Outlet	7.14	125.0	62.0	7.941	52.0	4.0	36.0	0.370	0.486	0.845
Mala Qara, Inlet	8.20	**1055.0**	**527.0**	**73.452**	102.0	18.0	110.0	0.359	2.010	0.945
Mala Qara, Outlet	7.60	76.0	38.0	5.956	20.0	6.0	13.0	0.354	0.577	0.470
Mnara, Inlet	7.80	482.0	240.0	7.941	82.0	14.0	124.0	0.370	0.835	0.520
Mnara, Outlet	7.28	104.0	52.0	7.941	50.0	12.0	114.0	0.370	0.655	0.470
Nawroz, Inlet	7.80	455.0	227.0	27.793	140.0	18.0	136.0	0.357	0.550	0.545
Nawroz, Outlet	7.40	38.0	19.0	7.941	60.0	6.0	24.0	0.349	0.544	0.450
Naz City, Inlet	7.64	522.0	261.0	15.882	124.0	20.0	118.0	0.349	1.528	0.770
Naz City, Outlet	7.55	77.0	38.0	9.926	26.0	6.0	24.0	0.344	0.739	0.720
Kurdistan, Inlet	**8.40**	341.0	170.0	7.941	110.0	10.0	84.0	0.349	0.595	1.095
Kurdistan, Outlet	7.44	14.0	**7.0**	7.941	22.0	**2.0**	88.0	0.344	0.450	0.495
Turaq, Inlet	7.70	428.0	215.0	13.896	**188.0**	8.0	32.0	0.341	1.585	**1.70**
Turaq, Outlet	6.85	20.0	10.0	7.941	14.0	6.0	**12.0**	**0.33**	0.364	1.570
Minimum	**6.56**	**9.00**	**7.00**	**3.97**	**8.0**	**2.0**	**12.0**	**0.33**	**0.33**	**0.42**
Maximum	**8.40**	**1055**	**527**	**73.45**	**188.0**	**26.0**	**166.0**	**0.41**	**2.59**	**1.70**
Mean	**7.51**	**285**	**148**	**16.74**	**73.5**	**10.5**	**77.2**	**0.36**	**1.14**	**0.78**

Table 2: Percent reduction of physico-chemical components of fifteen filtered water samples in Erbil.

Brands	**pH**	**EC µS cm^{-1}**	**TDS mg/l**	**Cl^- mg/l**	**Alk. mg/l**	**Acid. mg/l**	**Hard. mg/l**	**NO_2 mg/l**	**NO_3 mg/l**	**PO_4 mg/l**
32 Park	6.60	93.13	93.11	41.67	85.29	66.67	88.24	1.44	58.97	45.45
55 Q.	**0.13**	34.00	**18.75**	30.00	**31.82**	33.33	9.64	5.83	23.22	**4.49**
99 Zanko	6.13	96.88	**96.88**	25.00	59.68	50.00	90.48	**13.40**	77.57	16.30
Andaza	2.51	88.04	87.78	85.71	85.45	66.67	80.33	7.37	72.00	31.25
Bahari New	12.44	96.49	96.35	0.00	91.94	60.00	**92.41**	0.74	**86.43**	14.39
Bnaslawa	**15.14**	**98.32**	92.91	66.67	91.49	50.00	90.00	9.29	83.48	34.19
Deiy Zanko	11.11	91.67	91.83	62.50	90.20	25.00	87.50	3.49	68.90	**55.56**
Dream City	10.47	**20.45**	92.92	57.14	**92.54**	57.14	85.94	0.75	49.37	22.39
Kwestan	1.52	73.12	73.39	33.33	38.10	**84.62**	73.13	2.07	59.83	43.48
Mala Qara	7.32	92.80	92.79	**91.89**	80.39	66.67	88.18	1.45	71.29	50.26
Mnara	6.67	78.42	78.33	0.00	39.02	**14.29**	8.06	**0.00**	21.56	9.62
Nawroz	5.13	91.65	91.63	71.43	57.14	66.67	82.35	2.19	**1.09**	17.43
Naz City	1.18	85.25	85.44	37.50	79.03	70.00	79.66	1.49	51.64	6.49
Kurdistan	11.43	95.89	95.88	**0.00**	80.00	80.00	**4.76**	1.49	24.45	54.79
Turaq	11.04	95.33	95.35	42.86	92.55	25.00	62.50	4.57	77.03	7.37
Minimum	**0.13**	**20.45**	**18.75**	**0.00**	**31.82**	**14.29**	**4.76**	**0.00**	**1.09**	**4.49**
Maximum	**15.14**	**98.32**	**96.88**	**91.89**	**92.55**	**84.62**	**92.41**	**13.40**	**86.43**	**55.56**
Mean	**7.25**	**82.10**	**85.56**	**43.05**	**72.98**	**54.40**	**68.21**	**3.70**	**55.12**	**27.56**

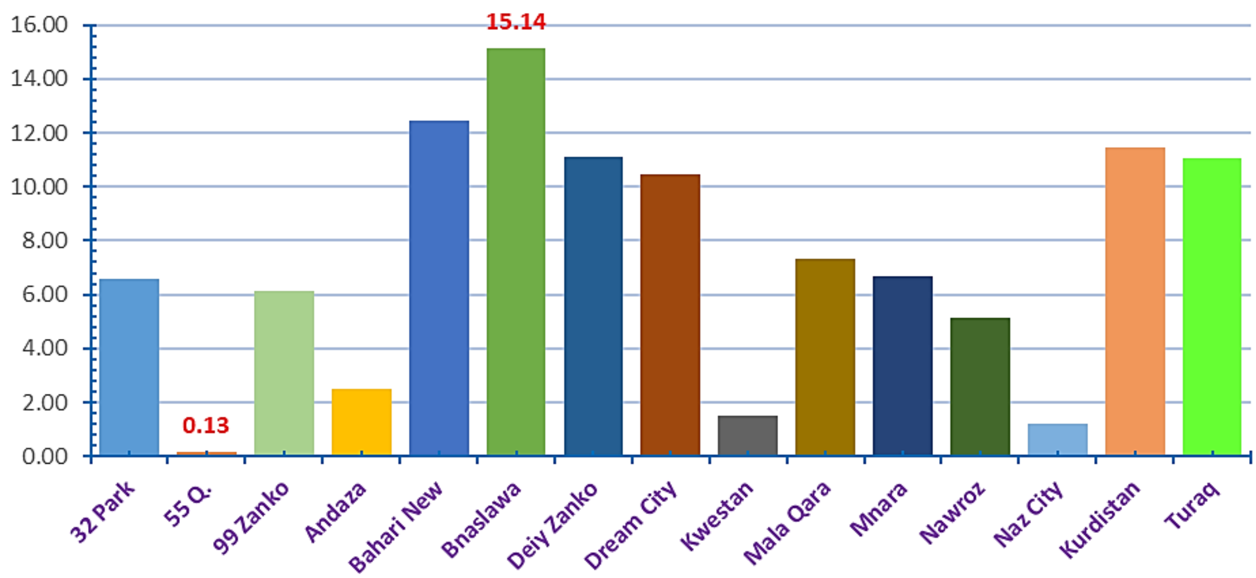

Figure 1: Percent reduction of pH values of fifteen home filtration system in in Erbil city.

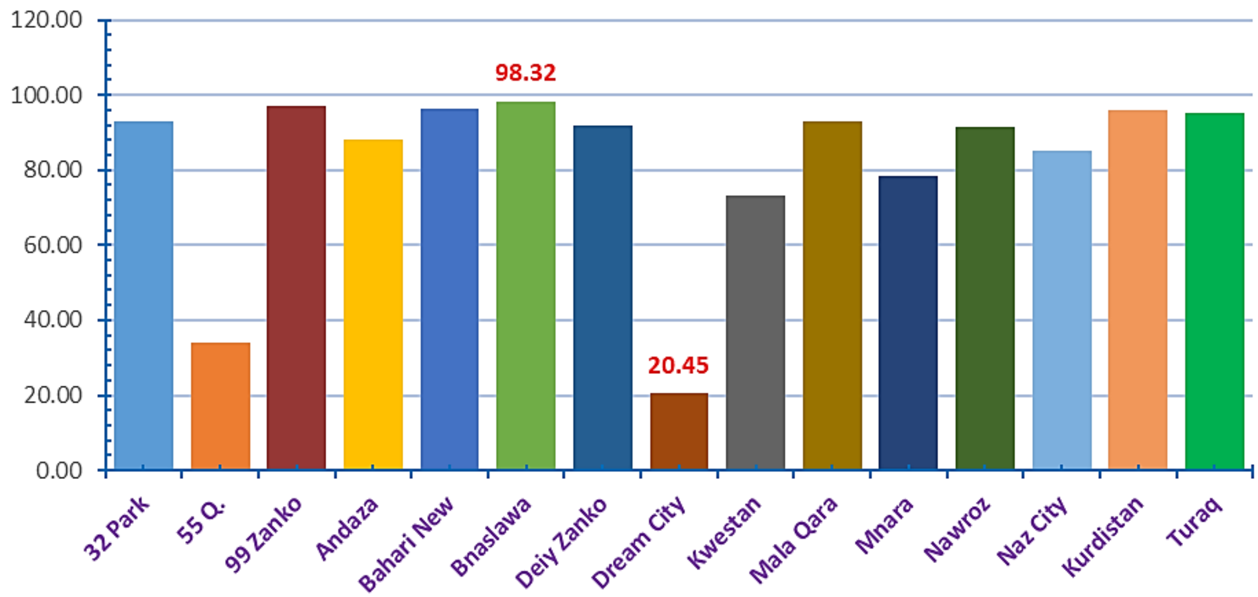

Figure 2: Percent reduction of EC values of fifteen home filtration system in in Erbil city.

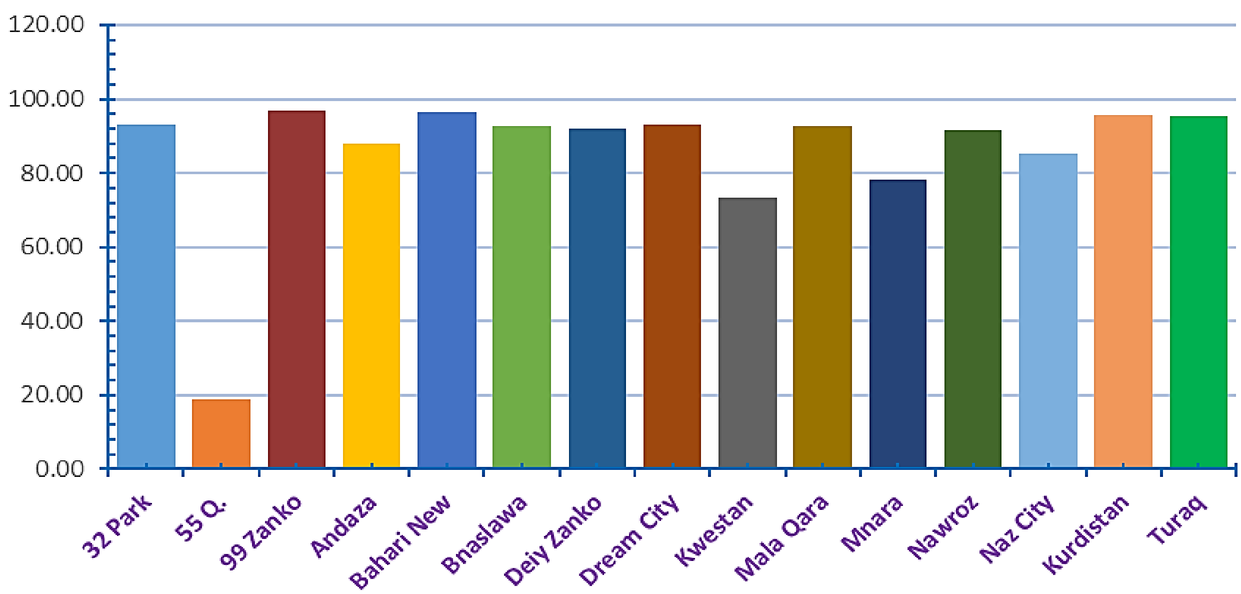

Figure 3: Percent reduction of TDS values of fifteen home filtration system in in Erbil

Chloride values (Table 1 and 2, Figure 4) ranged between 3.97 and 73.45 mg l^{-1}. The lowest level was recorded at Andaza outlet, whereas the highest concentration was measured at Mala Qara inlet during January 2024. The chloride removal efficiency ranged between 0% recorded at Bahari New, Mnara and Kurdistan to 91.98% measured at Mala Qara. The reduction of chloride in home water filter system is accomplished through the sand and carbon filters, they clog frequently by water suspended particles (Birhane *et al*., 2014).

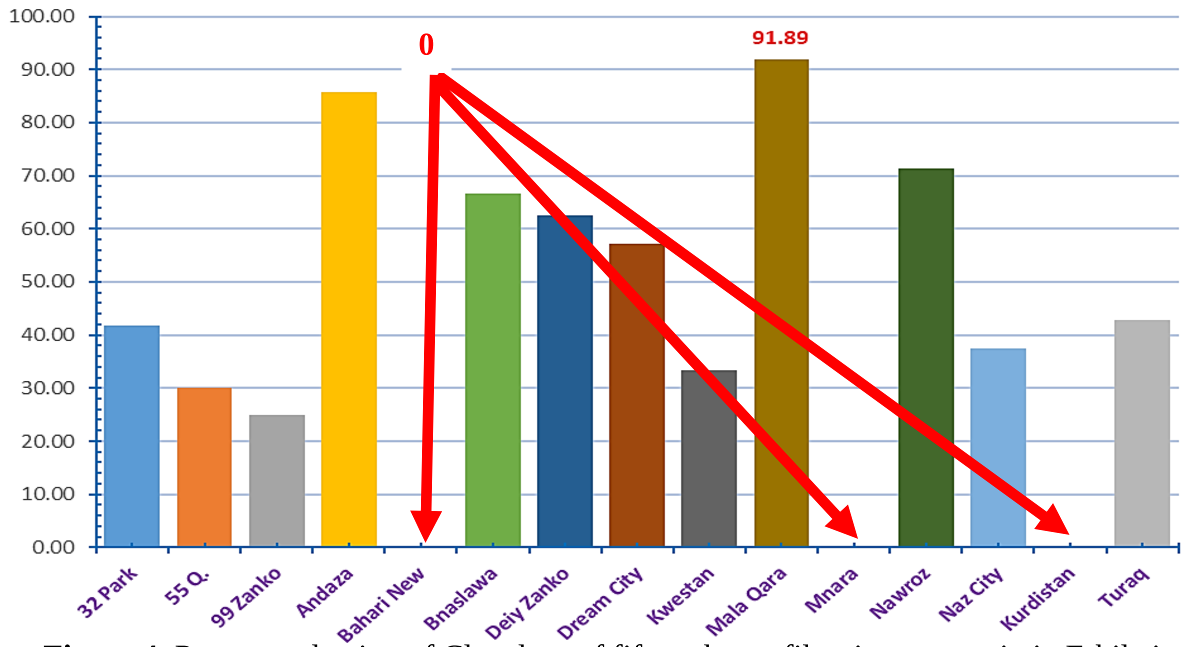

Figure 4: Percent reduction of Cl^- values of fifteen home filtration system in in Erbil city.

The Total Alkalinity value (Table 1 and 2, Figure 5) ranged between 8 and 188 mg $CaCO_3$ l^{-1}. The minimum value recorded at Bnaslawa outlet while the maximum value was measured at Turaq inlet. The highest percent of reduction of 93.54% was detected at Dream City and the lowest value of 31.82% was measured at 55 quarter with mean value of 72.28%. Generally, most of the studied home water filters showed moderate performance in removal efficiency of calcium carbonate as stated by Silva *et al*., 2012 and Al-Haddad *et al*. 2015.

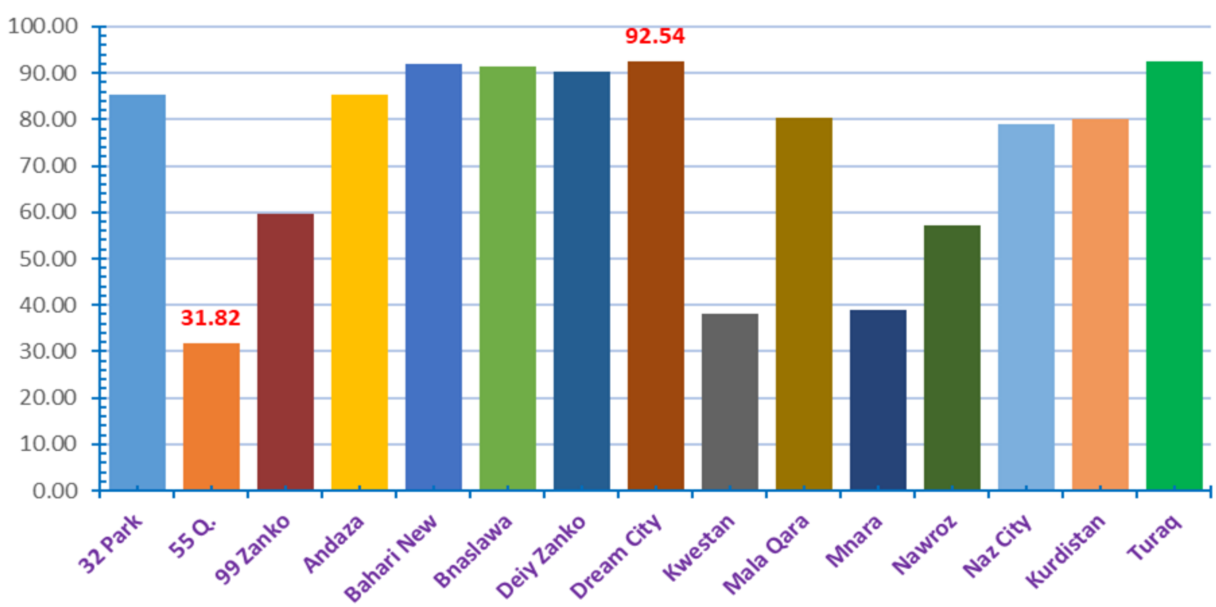

Figure 5: Percent reduction of Alkalinity values of fifteen home filtration system in in Erbil city.

Water acidity is its quantitative ability to respond to an assigned pH with a solid base (APHA, 2012). The Total acidity value (Table 1 and 2, Figure 6) ranged between 2 at Kurdistan outlet and 26 mg CaCO3 1^{-1} at Kwestan inlet. The highest percent of reduction of 84.62% was detected at Kwestan site and the lowest value of performance of 14.29% was measured at Mnara site. Generally, most of the studied home water filters showed moderate performance in removal efficiency of acidity as stated by Misra et al., 2015.

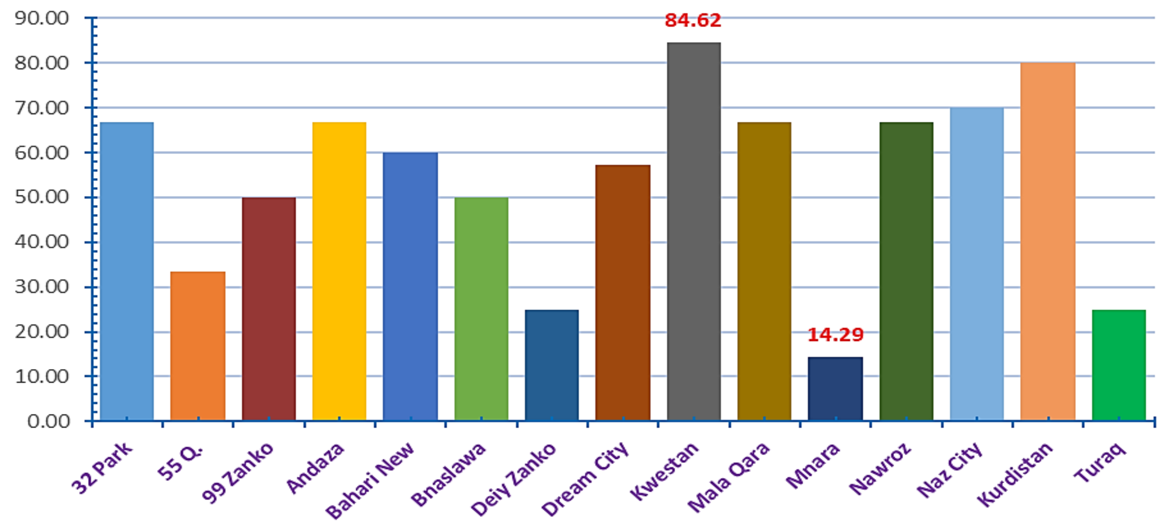

Figure 6: Percent reduction of Acidity values of fifteen home filtration system in in Erbil city.

In fresh water, the principal hardness – causing ions are calcium and magnesium, originated from the sedimentary rocks, the most common being limestone and chalk (WHO, 2011). The Total Hardness value (Table 1 and 2, Figure 7) ranged between 12 and 166 mg $CaCO_3$ 1^{-1}. The highest percent of reduction of 92.41% was detected at Bahari New site and the lowest value of 4.76% was measured at Kurdistan site.

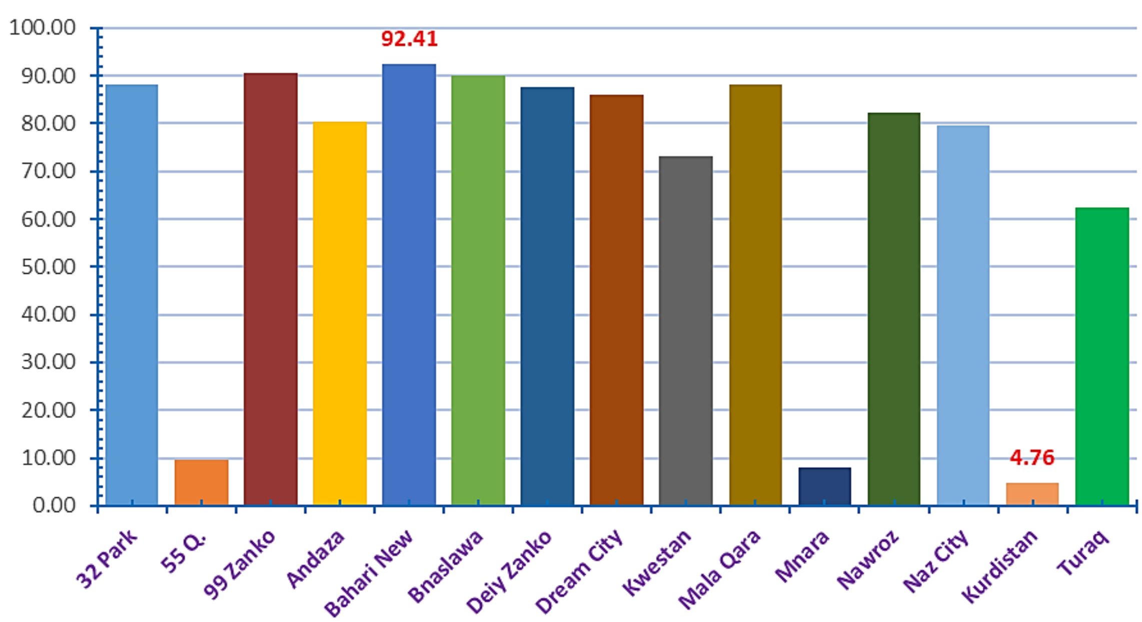

Figure 7: Percent reduction of Hardness values of fifteen home filtration system in in Erbil city.

Nitrite (NO_2) considered as an indicator of pollution in water when present in concentrations more than 1 mgl^{-1} as nitrite (USEPA, 2004), however the concentration of nitrite in natural waters were low because its unstable form of nitrogen and immediately oxidized to nitrate or reduced to ammonia (Goldman and Horne, 1983). The Nitrate NO_2 value (Table 1 and 2, Figure 8) of the inlet water and outlet water of the filters were same and ranged between 0.33 and 0.41 mg l^{-1}. The highest percent of reduction of 13.4% was calculated at 99 Zanko and the lowest percent of reduction of 0.00% was measured at Mnara site. Similar conclusions were observed by Adeyemo *et al*., 2015 and Birhane *et al*., 2014.

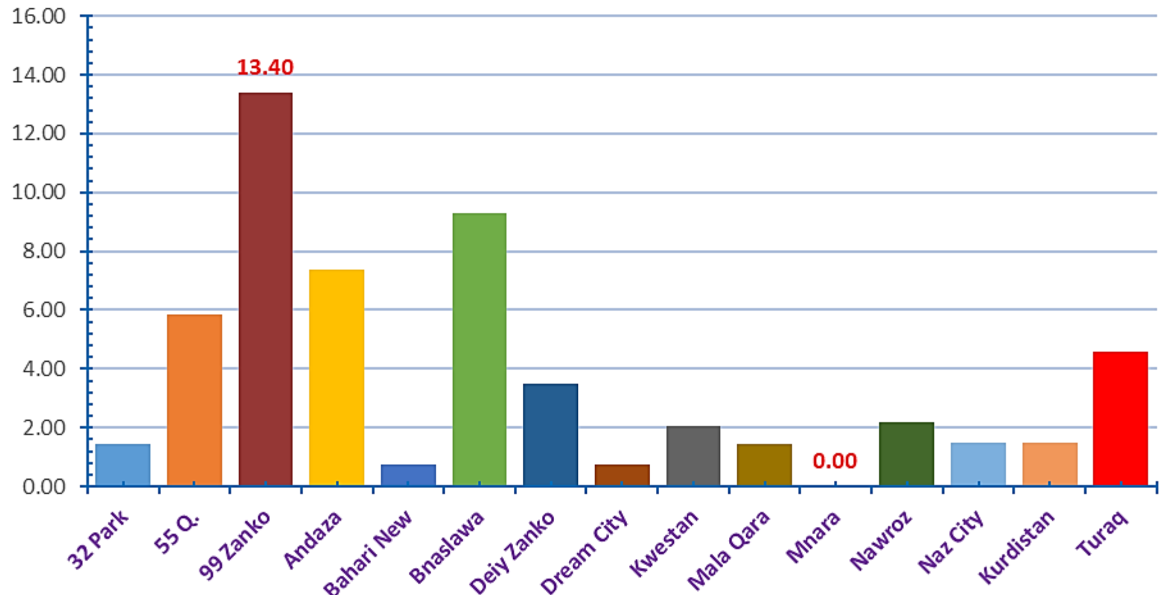

Figure 8: Percent reduction of NO_2 values of fifteen home filtration system in in Erbil city.

The Nitrate NO_3 value (Table 1 and 2, Figure 9) of the inlet water ranged between 0.33 mg I^{-1} recorded at Bnaslawa outlet and 2.59 mg I^{-1} recorded at 99 Zanko inlet. The highest percent of reduction of 86.43% was detected at Bahari New site and the lowest value of 1.09% was measured at Nawroz site. Generally, all types of home water filters showed low performance in NO_3 percent of reduction with mean value of 55.12%. We can conclude that the home water filter systems available commercially in Erbil city were not good performance for NO_3 removal efficiency.

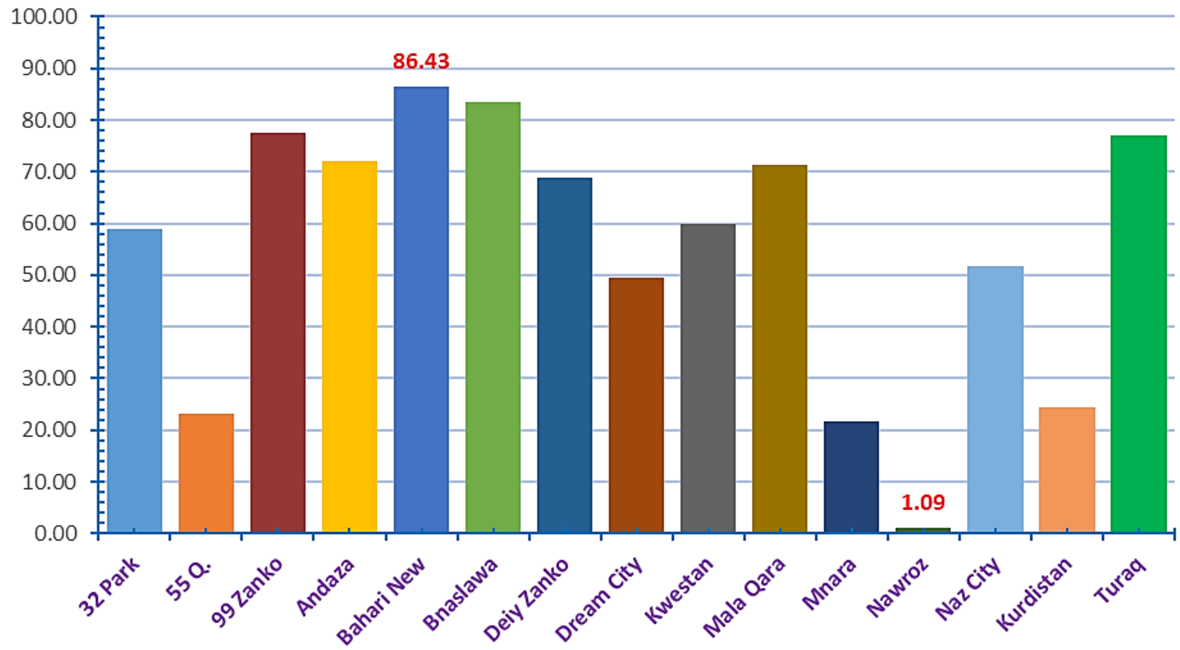

Figure 9: Percent reduction of NO_3 values of fifteen home filtration system in in Erbil city.

Phosphorus (PO_4^{-3}) is a major nutrient required for normal growth of all algae, its essential for almost all cellular processes, i.e. biosynthesis of nucleic acids. The phosphorus concentration is often growth limiting in natural aqueous habitat (Becker, 1995). The phosphate PO_4 level (Table 1 and 2, Figure 10) are similar in both inlet and outlet of the studied filters, i.e the performance of filters to remove the phosphate from water was very low and never exceed 55.6%. Generally, half of the filters can remove phosphate by a ratio not exceed 25% and only filters at Deiy Zanko and Kurdistan quarter removed phosphate by more than 50%.

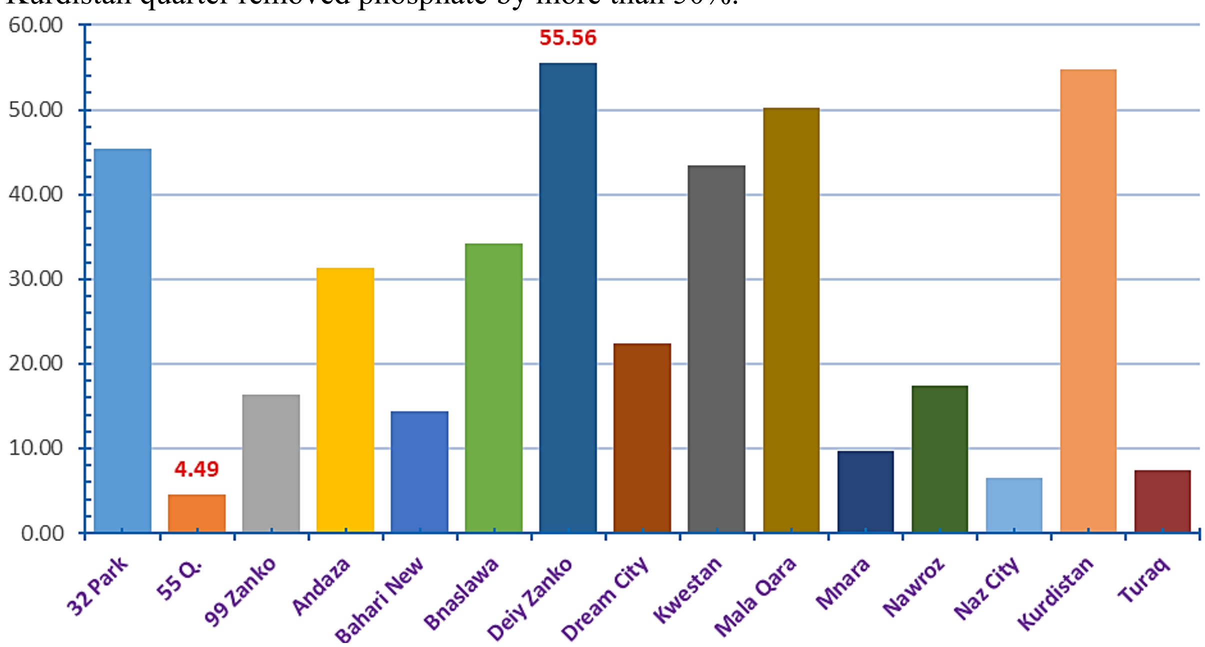

Figure10: Percent reduction of PO_4 values of fifteen home filtration system in in Erbil city.

Conclusions and Recommendations

During the studied period the following conclusions were noted:

1. Home water filters available in Erbil city are performing high percent of Reduction in improvement of EC, TDS, Alkalinity and Hardness.

2. The filters are poorly performing the percent of Reduction in improvement of pH, NO_3, NO_2 and PO_4.

3. Some water filters were performing zero percent of Reduction for Chloride and Nitrite.

4. Further analyses are required for heavy metal levels and bacteriological studies.

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