IDENTIFICATION OF CORRELATION BETWEEN TOTAL ORGANIC CARBON AND CONDUCTIVITY VALUES OF WATER FOR INJECTION LINE AND ESTABLISHING TOTAL ORGANIC CARBON RANGE FOR A SPECIFIC CONDUCTIVITY VALUE AT A WATER FOR INJECTION LINE / LOOP OF A SPECIFIC WATER SYSTEM

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The present study investigated the relationship between conductivity and total organic carbon (TOC) values in water for injection (WFI) systems at a pharmaceutical facility in Uttarakhand. Measurements were taken at the inlet and outlet of water for injection return loops across three separate blocks over a 90-day period from October 2024 to January 2025. The findings indicated that each block required a distinct total organic carbon range, as total organic carbon levels, while generally correlated with conductivity, were also influenced by factors such as pipeline length, diameter, and number of user points. Importantly, total organic carbon values could exceed specifications even if conductivity was within acceptable limits, highlighting the critical need for block-specific total organic carbon monitoring. Moreover, the total organic carbon range w.r.t. conductivity values can be defined based on the trends observed at specific water systems and these are more accurately illustrating the actual total organic carbon results and also can be hypothecated based on the online conductivity results of a water system or water for injection distribution system used in pharmaceutical industries. The study concludes that defining total organic carbon ranges relative to conductivity trends enhances water quality monitoring for pharmaceutical processes and ensures accurate control over organic contamination.

Keywords: *pharmaceutical facility, total organic carbon, water for injection, water quality*

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1. Introduction

Water for injections (WFI) is the prime requirement for any sterile drug product manufacturing unit in the pharmaceutical industry. WFI is used at various diversified stages of the sterile drug product production process. Water for injection (WFI) is widely used as a base component during manufacturing and for cleaning of equipment's, classified area, machine parts, utensils and accessories. Sometimes used as raw material also. Hence, contaminated / compromised Water for injection (WFI) may impact with the quality of manufactured drug product, also can cause product loss, may immense various side effects due to pharmacological effects and also destroy the image of the organization with patient safety issues / complaints (Brasil, 2005; da Silva et al., 2008; Schymanski et al., 2015; Sumanth and Moin, 2015, Carvalho et al., 2013; Petrovic et al., 2003). The water is formed by hydrogen bonds and oxygen. The chemical bonding of water breaks during reaction and forms hydrogen bonds. Therefore, water is considered as an excellent medium for solubilizing, absorbing, adsorbing, or suspending various types of compounds (Anvisa, 2019a; Fatta et al., 2007; Gaur et al., 2011).

In the sterile pharmaceutical industry, quality control units are monitoring the Water for injection (WFI) quality as required by the regulatory norms for sterile drug product manufacturers (Carvalho et al., 2013).

Consequently, to produce quality medicines, the Water for injection (WFI) used in the sterile formulations must have a higher degree of purity during its processing, distribution and storage systems (Moreno et al., 2011). The quality of distributed Water for injection (WFI) may depend upon various other factors also such as WFI distribution line length, WFI distribution line diameter, no. of user points and other few potential factors like environmental conditions of area. To avoid the probability of microbial ingress in drug products, filters and membranes are used prior to use in drug product batches. (Alves, 2013; Brasil, 2013).

Total organic carbon (TOC) and conductivity are very significant ways to assess the chemical purity and general cleanliness of the line. Hence, in water systems, TOC and conductivity can give important insight into the chemical purity of the water for injection (WFI).

All TOC analyzers only actually measure total carbon. Therefore, TOC analysis always requires some accounting for the inorganic carbon that is always present in the water. It measures the amount of inorganic carbon (IC) evolved from an acidified aliquot of a sample and the amount of total carbon (TC) present in the sample. Finally, TOC is calculated by subtraction of the IC value from the TC of the sample. This indicates that TOC measures the total amount of carbon bound in organic molecules in water.

Conductivity refers to a material's ability to allow the flow of electricity or heat. It's essentially the opposite of resistance, indicating how easily a current can pass through a substance. Conductivity is a measure of a solution's ability to conduct electricity. Since electricity needs charged particles to flow, there is generally a positive relationship between the concentration of ions and the ability of a solution to conduct electricity. Thus, conductivity meters are used in industry to measure ionic content in water supplies. This indicates that the conductivity of a solution is directly related to the concentration of ions in a solution. (de Matos et al., 2023)

TOC measures the total amount of carbon bound in organic molecules in water, while conductivity measures the water's ability to conduct electricity, influenced by dissolved ions. While many organic compounds can contribute to conductivity, some, like alcohol and ketones, are poor conductors. Other factors like temperature, pH, and the presence of specific inorganic ions can also affect conductivity, which makes the TOC and conductivity relationship as complex. However, the literature survey reveals that Total Organic Carbon (TOC) and electrical conductivity are often correlated.

Hence, this study was proposed to establish a correlation between the trends observed for TOC and conductivity values obtained for WFI return loop sample as per daily analysis results. This data is used to evaluate the conformity of WFI production and use in the manufacturing process as required by the regulatory bodies to meet the principles of cGMP and internationally accepted physical–chemical standards for water for injection (WFI).

2. Materials and Methods

Samples for water for injection (WFI) were collected on daily basis at 03 different manufacturing blocks in pharmaceutical industry located at Uttrakhand state for the period of 90 days starting from the month of October 2024 to January 2025. This period was chosen because it covers both seasons, including summer and winter period providing us with the highest assurance for potential assessment in results variation due to environmental changes so that the established range must cover all potential factors which may affect the TOC and conductivity correlation. For sampling purposes, few basic requirements were always considered. These are very specifically mentioned below:

1. Sample is collected from inlet and outlet openings of WFI return loop located in each water system of separate manufacturing blocks.

2. Sterilized bottles are used for collection of water for injection (WFI) sample.

3. Initially, approx. 500 ml of water for injection (WFI) was discarded.

4. Then, WFI is collected up to the bottle mouth level and immediately the cap is closed.

5. The WFI samples were transported in isothermal boxes.

Immediately after taking the sample, conductivity and TOC were analyzed by QC instruments.

For TOC analysis of water for Injection (WFI) sample, a calibrated and qualified equipment was used. This equipment was stabilized by applying a pressure of 200 kPa, a gas flow regulator at 150 ml/minute and water level of an internal humidifier was taken. Afterwards, the calibration curve was formed with five points, and observed reading was recorded. For conductivity, potentiometric method was used at a qualified and calibrated equipment.

2. Results and Discussion

This study is designed to establish a correlation between the TOC and conductivity values of WFI return loop observed in last few months' analysis.

Table 1 enlists test results for all the samples taken for water for Injection (WFI) for 90 days.

Based on the available data for the last few months for WFI return loop, the correlation factor between TOC and conductivity values were established. Then, average value and standard deviation of correlation factors were taken. Below formulas were used for this calculation:

Correlation factor for a day = Obtained value of TOC / Obtained value of conductivity;

Average of correlation factor = Total of all correlation factors / Total number of observations;

$$\sigma = \sqrt{(\sum (x - \mu)^2 / n)},$$

where σ - standard deviation of correlation factor; x - each value for correlation factor; μ - mean value of correlation factor; n - total number of observations.

Table 1. *Water for injection (WFI) Daily QC analysis results for TOC and conductivity*

Sample Collection	Block - 1					Block - 2					Block - 3				
	Inlet point		Outlet point		Differential coefficient (Inlet & Outlet TOC value)	Inlet point		Outlet point		Differential coefficient (Inlet & Outlet TOC value)	Inlet point		Outlet point		Differential coefficient (Inlet & Outlet TOC value)
	Conductivity (µS/cm)	TOC (ppb)	Conductivity (µS/cm)	TOC (ppb)		Conductivity (µS/cm)	TOC (ppb)	Conductivity (µS/cm)	TOC (ppb)		Conductivity (µS/cm)	TOC (ppb)	Conductivity (µS/cm)	TOC (ppb)	
1st day	0.56	185.7	0.59	196.8	0.06	0.52	142.1	0.48	149.8	0.05	0.49	147.8	0.59	144.2	-0.02
2nd day	0.46	143.5	0.47	149.9	0.04	0.44	153.3	0.49	155.2	0.01	0.40	152.0	0.69	146.1	-0.04
3rd day	0.43	158.0	0.58	138.6	-0.14	0.43	160.5	0.44	168.4	0.05	0.54	153.4	0.68	148.3	-0.03
4th day	0.45	144.3	0.54	145.6	0.01	0.51	148.9	0.52	172.1	0.13	0.46	151.8	0.69	154.4	0.02
5th day	0.44	170.4	0.54	149.3	-0.14	0.49	176.8	0.56	166.8	-0.06	0.58	185.9	0.79	198.9	0.07
6th day	0.42	158.2	0.48	154.1	-0.03	0.43	169.1	0.38	159.9	-0.06	0.55	182.2	0.56	194.2	0.06
7th day	0.41	313.8	0.47	302.1	-0.04	0.45	110.0	0.41	119.9	0.08	0.58	112.7	0.43	124.8	0.10
8th day	0.43	187.2	0.49	194.3	0.04	0.50	183.6	0.56	143.8	-0.28	0.40	186.9	0.53	191.8	0.03
9th day	0.49	221.0	0.59	214.5	-0.03	0.35	249.2	0.42	224.6	-0.11	0.50	247.5	0.59	238.5	-0.04
10th day	0.41	152.0	0.45	154.2	0.01	0.48	130.5	0.43	148.5	0.12	0.54	135.6	0.58	144.6	0.06
11th day	0.52	132.3	0.57	126.2	-0.05	0.48	130.2	0.48	134.4	0.03	0.46	131.3	0.57	142.7	0.08
12th day	0.52	346.6	0.56	303.4	-0.14	0.42	202.3	0.44	216.3	0.06	0.49	202.0	0.56	221.5	0.09
13th day	0.48	196.9	0.54	194.7	-0.01	0.38	205.9	0.39	201.2	-0.02	0.58	201.5	0.55	232.6	0.13
14th day	0.35	91.1	0.43	99.7	0.09	0.44	100.4	0.41	104.6	0.04	0.48	100.7	0.52	118.9	0.15
15th day	0.39	139.9	0.47	134.5	-0.04	0.42	134.4	0.47	136.3	0.01	0.56	139.5	0.63	145.6	0.04
16th day	0.44	140.6	0.34	138.4	-0.02	0.43	145.2	0.46	155.1	0.06	0.59	147.7	0.68	149.8	0.01
17th day	0.40	110.3	0.41	117.2	0.06	0.44	142.7	0.42	158.7	0.10	0.35	157.6	0.67	168.8	0.07
18th day	0.48	165.2	0.43	164.8	0.00	0.42	160.8	0.45	159.9	-0.01	0.50	164.8	0.64	174.9	0.06
19th day	0.40	155.0	0.44	154.3	0.00	0.53	170.8	0.59	179.9	0.05	0.52	183.3	0.64	186.5	0.02
20th day	0.47	288.9	0.46	275.9	-0.05	0.49	131.2	0.45	136.2	0.04	0.59	177.4	0.55	186.6	0.05
21st day	0.45	223.7	0.44	221.4	-0.01	0.39	248.1	0.47	243.3	-0.02	0.41	260.7	0.45	257.9	-0.01
22nd day	0.50	142.4	0.52	132.2	-0.08	0.38	152.4	0.45	144.4	-0.06	0.52	156.0	0.55	176.5	0.12
23rd day	0.50	138.9	0.56	128.6	-0.08	0.47	144.0	0.44	148.3	0.03	0.42	145.0	0.45	154.7	0.06
24th day	0.52	288.0	0.57	245.3	-0.17	0.50	184.7	0.52	194.2	0.05	0.62	184.2	0.65	182.3	-0.01
25th day	0.47	242.6	0.57	241.4	0.00	0.54	224.1	0.56	214.5	-0.04	0.50	258.2	0.55	245.8	-0.05
26th day	0.38	16.5	0.48	35.0	0.53	0.61	25.2	0.59	27.4	0.08	0.45	20.1	0.55	44.7	0.55
27th day	0.41	53.5	0.49	59.8	0.11	0.26	54.0	0.32	94.4	0.43	0.49	54.9	0.59	56.3	0.02
28th day	0.69	106.9	0.58	114.7	0.07	0.38	103.5	0.43	111.9	0.08	0.47	162.3	0.48	154.8	-0.05
29th day	0.65	257.9	0.69	224.8	-0.15	0.55	192.3	0.42	194.8	0.01	0.31	180.4	0.35	187.4	0.04
30th day	0.71	168.0	0.74	164.2	-0.02	0.41	179.8	0.45	157.6	-0.14	0.31	184.5	0.36	188.6	0.02
31st day	0.65	25.0	0.59	76.0	0.67	0.69	23.4	0.75	47.7	0.51	0.45	101.9	0.54	114.7	0.11
32nd day	0.39	129.6	0.48	122.7	-0.06	0.73	147.0	0.77	149.0	0.01	0.61	151.6	0.64	144.8	-0.05
33rd day	0.54	208.3	0.54	198.5	-0.05	0.50	136.5	0.48	145.7	0.06	0.54	134.8	0.53	144.3	0.07
34th day	0.45	121.4	0.46	128.2	0.05	0.52	119.6	0.45	154.8	0.23	0.48	117.7	0.54	145.7	0.19

Sample Collec-tion	Block - 1					Block - 2					Block - 3				
	Inlet point		Outlet point		Differential coefficient (Inlet & Outlet TOC value)	Inlet point		Outlet point		Differential coefficient (Inlet & Outlet TOC value)	Inlet point		Outlet point		Differential coefficient (Inlet & Outlet TOC value)
	Conductivity (µS/cm)	TOC (ppb)	Conductivity (µS/cm)	TOC (ppb)		Conductivity (µS/cm)	TOC (ppb)	Conductivity (µS/cm)	TOC (ppb)		Conductivity (µS/cm)	TOC (ppb)	Conductivity (µS/cm)	TOC (ppb)	
35th day	0.40	105.9	0.48	106.8	0.01	0.48	103.9	0.58	132.5	0.22	0.51	106.5	0.53	154.7	0.31
36th day	0.50	216.3	0.54	225.3	0.04	0.50	158.7	0.61	178.9	0.11	0.49	151.8	0.50	142.8	-0.06
37th day	0.49	234.1	0.56	212.2	-0.10	0.45	242.2	0.54	214.6	-0.13	0.47	240.3	0.49	237.6	-0.01
38th day	0.47	69.2	0.57	99.4	0.30	0.55	74.0	0.58	86.6	0.15	0.48	77.9	0.42	97.8	0.20
39th day	0.47	86.2	0.59	88.5	0.03	0.43	88.1	0.49	99.1	0.11	0.40	89.0	0.50	97.9	0.09
40th day	0.37	375.2	0.48	312.2	-0.20	0.36	223.9	0.38	234.7	0.05	0.52	238.0	0.51	214.0	-0.11
41st day	0.52	255.9	0.54	254.2	-0.01	0.55	257.8	0.52	264.7	0.03	0.50	260.0	0.53	242.1	-0.07
42nd day	0.40	110.3	0.49	124.6	0.11	0.47	232.7	0.56	239.8	0.03	0.49	249.7	0.54	238.6	-0.05
43rd day	0.49	375.6	0.47	345.5	-0.09	0.56	313.3	0.54	332.6	0.06	0.58	318.6	0.49	306.7	-0.04
44th day	0.51	297.6	0.54	277.5	-0.07	0.46	291.1	0.41	284.1	-0.02	0.45	278.5	0.35	272.4	-0.02
45th day	0.43	154.1	0.53	155.1	0.01	0.48	156.7	0.53	159.1	0.02	0.48	169.0	0.54	178.3	0.05
46th day	0.42	47.6	0.47	44.5	-0.07	0.48	57.6	0.56	68.7	0.16	0.58	64.1	0.64	69.3	0.08
47th day	0.48	34.4	0.68	124.5	0.72	0.52	40.0	0.58	42.1	0.05	0.64	40.1	0.66	54.6	0.27
48th day	0.50	159.9	0.71	169.4	0.06	0.51	36.6	0.57	52.7	0.31	0.53	45.3	0.56	48.9	0.07
49th day	0.40	136.0	0.49	126.5	-0.08	0.39	172.4	0.45	188.5	0.09	0.36	190.2	0.46	192.4	0.01
50th day	0.41	90.3	0.54	92.5	0.02	0.50	111.8	0.49	131.5	0.15	0.50	117.8	0.56	143.5	0.18
51st day	0.53	138.5	0.57	137.4	-0.01	0.44	148.8	0.49	144.1	-0.03	0.39	166.9	0.49	153.7	-0.09
52nd day	0.41	32.6	0.44	87.6	0.63	0.69	34.5	0.74	39.6	0.13	0.48	36.8	0.58	42.8	0.14
53rd day	0.36	99.2	0.38	84.8	-0.17	0.38	96.0	0.62	116.0	0.17	0.43	95.5	0.53	84.5	-0.13
54th day	0.52	28.0	0.56	42.9	0.35	0.53	28.9	0.41	49.0	0.41	0.53	23.5	0.58	45.6	0.48
55th day	0.53	142.1	0.59	134.8	-0.05	0.59	166.0	0.42	144.6	-0.15	0.53	172.1	0.57	168.3	-0.02
56th day	0.35	25.2	0.47	96.1	0.74	0.39	25.6	0.48	38.9	0.34	0.39	25.6	0.45	43.6	0.41
57th day	0.32	137.6	0.42	102.8	-0.34	0.35	165.3	0.54	184.4	0.10	0.40	167.1	0.46	178.4	0.06
58th day	0.42	76.2	0.48	74.5	-0.02	0.44	101.7	0.43	117.9	0.14	0.37	106.9	0.47	115.9	0.08
59th day	0.57	28.8	0.47	43.8	0.34	0.57	28.8	0.67	38.7	0.26	0.42	31.7	0.44	43.8	0.28
60th day	0.36	80.0	0.46	75.6	-0.06	0.37	132.1	0.49	149.6	0.12	0.35	137.4	0.38	132.8	-0.03
61st day	0.37	127.1	0.48	109.4	-0.16	0.36	121.0	0.41	101.1	-0.20	0.35	123.4	0.42	136.5	0.10
62nd day	0.36	48.3	0.35	75.6	0.36	0.35	47.4	0.42	107.1	0.56	0.37	51.3	0.38	78.4	0.35
63rd day	0.40	173.2	0.61	164.4	-0.05	0.34	207.8	0.36	218.9	0.05	0.37	231.8	0.37	232.9	0.00
64th day	0.42	25.1	0.65	44.9	0.44	0.40	23.5	0.48	48.5	0.52	0.38	25.4	0.36	35.8	0.29
65th day	0.35	21.2	0.66	42.6	0.50	0.37	18.4	0.44	36.2	0.49	0.34	17.0	0.37	32.1	0.47
66th day	0.35	42.1	0.37	43.5	0.03	0.37	41.8	0.47	61.7	0.32	0.35	43.5	0.39	46.8	0.07
67th day	0.50	113.2	0.51	104.7	-0.08	0.34	133.0	0.46	148.4	0.10	0.50	123.8	0.58	112.3	-0.10
68th day	0.37	257.3	0.45	247.6	-0.04	0.35	88.8	0.55	94.8	0.06	0.40	88.6	0.47	87.5	-0.01

Sample Collec-tion	**Block - 1**					**Block - 2**					**Block - 3**				
	Inlet point		**Outlet point**		**Differential coefficient (Inlet & Outlet TOC value)**	**Inlet point**		**Outlet point**		**Differential coefficient (Inlet & Outlet TOC value)**	**Inlet point**		**Outlet point**		**Differential coefficient (Inlet & Outlet TOC value)**
	Conductivity (µS/cm)	**TOC (ppb)**	**Conductivity (µS/cm)**	**TOC (ppb)**		**Conductivity (µS/cm)**	**TOC (ppb)**	**Conductivity (µS/cm)**	**TOC (ppb)**		**Conductivity (µS/cm)**	**TOC (ppb)**	**Conductivity (µS/cm)**	**TOC (ppb)**	
69th day	0.33	49.9	0.48	59.8	0.17	0.31	55.3	0.54	65.6	0.16	0.33	54.4	0.43	55.2	0.01
70th day	0.33	168.2	0.39	162.6	-0.03	0.39	43.7	0.48	64.9	0.33	0.32	45.7	0.54	44.8	-0.02
71st day	0.36	261.7	0.47	264.1	0.01	0.34	144.2	0.39	132.1	-0.09	0.32	133.7	0.48	130.7	-0.02
72nd day	0.32	49.6	0.42	78.3	0.37	0.39	46.5	0.43	66.8	0.30	0.38	49.0	0.42	69.8	0.30
73rd day	0.50	86.5	0.58	81.3	-0.06	0.36	134.0	0.42	136.8	0.02	0.62	184.2	0.65	182.6	-0.01
74th day	0.35	180.6	0.45	187.8	0.04	0.39	180.9	0.44	179.8	-0.01	0.34	203.4	0.39	231.4	0.12
75th day	0.69	249.2	0.74	256.4	0.03	0.51	253.1	0.48	235.4	-0.08	0.29	261.5	0.38	254.5	-0.03
76th day	0.38	163.6	0.58	182.6	0.10	0.35	197.7	0.54	184.4	-0.07	0.33	252.0	0.43	256.2	0.02
77th day	0.33	36.7	0.51	45.8	0.20	0.36	34.8	0.46	42.8	0.19	0.47	36.9	0.56	39.9	0.08
78th day	0.46	74.1	0.54	79.4	0.07	0.47	71.6	0.49	84.8	0.16	0.40	71.1	0.52	74.3	0.04
79th day	0.50	42.5	0.55	46.8	0.09	0.48	46.7	0.52	86.9	0.46	0.47	51.2	0.57	81.6	0.37
80th day	0.54	43.2	0.59	48.2	0.10	0.56	70.2	0.53	85.6	0.18	0.53	44.6	0.57	74.6	0.40
81st day	0.53	74.7	0.57	73.6	-0.01	0.59	73.6	0.57	79.0	0.07	0.53	74.6	0.58	73.2	-0.02
82nd day	0.60	187.1	0.64	178.5	-0.05	0.52	197.5	0.59	184.6	-0.07	0.50	199.8	0.66	188.3	-0.06
83rd day	0.53	54.0	0.51	68.3	0.21	0.39	40.2	0.43	47.5	0.15	0.69	42.7	0.72	43.7	0.02
84th day	0.69	186.1	0.71	189.3	0.02	0.41	180.0	0.54	199.1	0.10	0.26	182.8	0.34	184.9	0.01
85th day	0.47	78.9	0.68	87.9	0.10	0.55	84.7	0.59	95.8	0.12	0.65	79.8	0.82	79.7	0.00
86th day	0.54	139.2	0.58	137.6	-0.01	0.59	145.7	0.65	135.7	-0.07	0.79	140.1	0.83	142.1	0.01
87th day	0.71	73.8	0.69	76.8	0.04	0.53	72.8	0.63	82.7	0.12	0.76	66.7	0.73	68.9	0.03
88th day	0.51	186.0	0.61	189.1	0.02	0.53	186.5	0.67	184.3	-0.01	0.82	191.4	0.84	195.6	0.02
89th day	0.55	149.1	0.63	154.3	0.03	0.65	146.8	0.78	163.1	0.10	0.52	148.6	0.56	154.8	0.04
90th day	0.41	68.7	0.64	77.0	0.11	0.55	62.5	0.57	98.7	0.37	0.47	64.1	0.49	76.4	0.16
Average	0.46	140.79	0.53	142.20	0.06	0.46	130.24	0.50	137.84	0.10	0.48	136.19	0.54	141.99	0.07
Standard Deviation	0.09	84.94	0.09	72.88	0.20	0.09	69.38	0.09	62.98	0.16	0.11	72.02	0.11	67.44	0.14

The separate study was performed for each return loop available in respective blocks.

Below are the block-wise details for calculation-based correlation factors (Table 2).

Table 2. *Calculation for correlation factor*

Analysis Day	Block-1 (Inlet)	Block-1 (Outlet)	Block-2 (Inlet)	Block-2 (Outlet)	Block-3 (Inlet)	Block-3 (Outlet)
1st day	331.607	333.559	273.269	312.083	301.633	244.407
2nd day	311.957	318.936	348.409	316.735	380.000	211.739
3rd day	367.442	238.966	373.256	382.727	284.074	218.088
4th day	320.667	269.630	291.961	330.962	330.000	223.768
5th day	387.273	276.481	360.816	297.857	320.517	251.772
6th day	376.667	321.042	393.256	420.789	331.273	346.786
7th day	765.366	642.809	244.444	292.439	194.310	290.233
8th day	435.349	396.531	367.200	256.786	467.250	361.887
9th day	451.020	363.559	712.000	534.762	495.000	404.237
10th day	370.732	342.667	271.875	345.349	251.111	249.310
11th day	254.423	221.456	271.250	280.000	285.435	250.351
12th day	666.538	541.786	481.667	491.591	412.245	395.536
13th day	410.208	360.556	541.842	515.897	347.414	422.909
14th day	260.400	231.953	228.182	255.122	209.792	228.654
15th day	358.718	286.170	320.000	290.000	249.107	231.111
16th day	319.545	407.059	337.674	337.174	250.339	220.294
17th day	275.750	285.854	324.318	377.857	450.286	251.940
18th day	344.167	383.256	382.857	355.333	329.600	273.281
19th day	387.500	350.682	322.264	304.915	352.500	291.406
20th day	614.681	599.717	267.755	302.667	300.678	339.273
21st day	497.111	503.182	636.154	517.660	635.854	573.111
22nd day	284.800	254.231	401.053	320.889	300.000	320.909
23rd day	277.800	229.643	306.383	337.045	345.238	343.778
24th day	553.846	430.351	369.400	373.462	297.097	280.462
25th day	516.170	423.509	415.000	383.036	516.400	446.909
26th day	43.342	72.875	41.344	46.475	44.689	81.273
27th day	130.366	121.939	207.769	295.000	112.061	95.424
28th day	154.928	197.759	272.368	260.233	345.319	322.500
29th day	396.769	325.797	349.636	463.810	581.935	535.429
30th day	236.620	221.892	438.537	350.222	595.161	523.889
31st day	38.400	128.780	33.884	63.573	226.444	212.407
32nd day	332.308	255.625	201.370	193.506	248.525	226.250
33rd day	385.741	367.593	273.000	303.542	249.630	272.264
34th day	269.778	278.696	230.000	344.000	245.208	269.815
35th day	264.750	222.500	216.458	228.448	208.824	291.887
36th day	432.600	417.222	317.400	293.279	309.796	285.600
37th day	477.755	378.929	538.222	397.407	511.277	484.898
38th day	147.319	174.298	134.455	149.293	162.292	232.857
39th day	183.319	149.932	204.907	202.327	222.500	195.800
40th day	1014.054	650.417	621.944	617.632	457.692	419.608
41st day	492.115	470.648	468.727	509.038	520.000	456.792
42nd day	275.750	254.286	495.106	428.214	509.592	441.852

Analysis Day	Block-1 (Inlet)	Block-1 (Outlet)	Block-2 (Inlet)	Block-2 (Outlet)	Block-3 (Inlet)	Block-3 (Outlet)
43rd day	766.531	735.106	559.464	615.926	549.310	625.918
44th day	583.529	513.889	632.826	693.024	618.889	778.286
45th day	358.372	292.642	326.458	300.226	352.083	330.185
46th day	113.333	94.681	120.000	122.589	110.517	108.281
47th day	71.604	183.088	77.000	72.552	62.656	82.727
48th day	319.800	238.592	71.765	92.421	85.472	87.321
49th day	340.000	258.102	442.051	418.800	528.333	418.261
50th day	220.220	171.370	223.600	268.388	235.600	256.250
51st day	261.321	241.053	338.182	294.122	427.949	313.673
52nd day	79.512	199.182	49.942	53.568	76.667	73.793
53rd day	275.417	223.026	252.500	187.081	221.977	159.434
54th day	53.788	76.554	54.509	119.390	44.415	78.621
55th day	268.113	228.475	281.356	344.286	324.717	295.263
56th day	72.086	204.553	65.641	81.042	65.641	96.889
57th day	430.000	244.762	472.286	341.481	417.750	387.826
58th day	181.429	155.208	231.136	274.186	288.919	246.596
59th day	50.474	93.191	50.526	57.761	75.476	99.545
60th day	222.222	164.348	357.027	305.306	392.571	349.474
61st day	343.514	227.938	336.111	246.634	352.571	325.000
62nd day	134.250	216.114	135.486	255.024	138.649	206.316
63rd day	433.000	269.426	611.176	608.111	626.486	629.459
64th day	59.738	69.031	58.675	101.125	66.842	99.444
65th day	60.629	64.515	49.622	82.182	49.941	86.757
66th day	120.400	117.676	113.081	131.319	124.200	120.000
67th day	226.400	205.294	391.176	322.609	247.600	193.621
68th day	695.405	550.222	253.714	172.364	221.500	186.170
69th day	151.182	124.646	178.419	121.481	164.909	128.372
70th day	509.697	416.923	112.051	135.208	142.813	82.963
71st day	726.944	561.915	424.118	338.795	417.813	272.292
72nd day	155.000	186.429	119.231	155.349	128.947	166.190
73rd day	173.000	140.172	372.222	325.714	297.097	280.923
74th day	516.000	417.333	463.846	408.636	598.235	593.333
75th day	361.159	346.486	496.275	490.313	901.724	669.737
76th day	430.526	314.828	564.857	341.481	763.636	595.814
77th day	111.303	89.804	96.639	93.130	78.489	71.250
78th day	161.130	147.037	152.277	172.959	177.750	142.885
79th day	85.040	85.091	97.292	167.115	108.915	143.158
80th day	79.926	81.695	125.304	161.585	84.170	130.877
81st day	140.887	129.140	124.695	138.561	140.755	126.207
82nd day	311.833	278.906	379.808	312.881	399.600	285.303
83rd day	101.887	133.922	103.154	110.395	61.884	60.694
84th day	269.710	266.620	439.024	368.704	703.077	543.824
85th day	167.915	129.324	154.000	162.373	122.769	97.195

Analysis Day	Block-1 (Inlet)	Block-1 (Outlet)	Block-2 (Inlet)	Block-2 (Outlet)	Block-3 (Inlet)	Block-3 (Outlet)
86th day	257.778	237.241	246.949	208.769	177.342	171.205
87th day	103.915	111.304	137.358	131.270	87.763	94.384
88th day	364.706	310.000	351.887	275.075	233.415	232.857
89th day	271.091	244.921	225.846	209.115	285.769	276.429
90th day	167.488	120.281	113.636	173.158	136.383	155.918
Average	308.61	273.50	292.46	284.92	301.20	277.53
Standard Deviation	189.50	145.98	163.28	142.68	182.94	158.31

Average value and standard deviation of correlation factors were used to establish minimum and maximum value of correlation factors based on the data:

Minimum established value of correlation factor = Average of correlation factor – Standard Deviation of correlation factor;

Maximum established value of correlation factor = Average of correlation factor + Standard Deviation of correlation factor.

Below are the minimum and maximum established value of correlation factors for each block / loop (Table 3).

Table 3. *Minimum and maximum established value of correlation factor*

Established value of correlation factor	Block-1 (Inlet)	Block-1 (Outlet)	Block-2 (Inlet)	Block-2 (Outlet)	Block-3 (Inlet)	Block-3 (Outlet)
Minimum	119.11	127.52	129.18	142.24	118.27	119.22
Maximum	498.11	419.48	455.74	427.60	484.14	435.84

These minimum and maximum values of correlation factors were used to demonstrate a reference range for TOC value based on the obtained conductivity value:

Minimum TOC = Obtained value of conductivity · Minimum established value of correlation factor:

Maximum TOC = Obtained value of conductivity · Maximum established value of correlation factor.

Based on the minimum and maximum established value of correlation factor, a TOC range has been defined for each block / return loop sampling points at a specified value of conductivity.

Below are these values (Table 4).

Table 4. *Conductivity based TOC range for each block / WFI return loop sampling points*

Conductivity (μs/cm)	TOC Range (ppb) for Block-1 (Inlet)		TOC Range (ppb) for Block-1 (Outlet)		TOC Range (ppb) for Block-2 (Inlet)		TOC Range (ppb) for Block-2 (Outlet)		TOC Range (ppb) for Block-3 (Inlet)		TOC Range (ppb) for Block-3 (Outlet)	
	From	**To**	**From**	**To**	**From**	**To**	**From**	**To**	**From**	**To**	**From**	**To**
0.01	1.19	4.98	1.28	4.19	1.29	4.56	1.42	4.28	1.18	4.84	1.19	4.36
0.02	2.38	9.96	2.55	8.39	2.58	9.11	2.84	8.55	2.37	9.68	2.38	8.72
0.03	3.57	14.94	3.83	12.58	3.88	13.67	4.27	12.83	3.55	14.52	3.58	13.08
0.04	4.76	19.92	5.10	16.78	5.17	18.23	5.69	17.10	4.73	19.37	4.77	17.43
0.05	5.96	24.91	6.38	20.97	6.46	22.79	7.11	21.38	5.91	24.21	5.96	21.79
0.06	7.15	29.89	7.65	25.17	7.75	27.34	8.53	25.66	7.10	29.05	7.15	26.15
0.07	8.34	34.87	8.93	29.36	9.04	31.90	9.96	29.93	8.28	33.89	8.35	30.51
0.08	9.53	39.85	10.20	33.56	10.33	36.46	11.38	34.21	9.46	38.73	9.54	34.87
0.09	10.72	44.83	11.48	37.75	11.63	41.02	12.80	38.48	10.64	43.57	10.73	39.23
0.10	11.91	49.81	12.75	41.95	12.92	45.57	14.22	42.76	11.83	48.41	11.92	43.58
0.11	13.10	54.79	14.03	46.14	14.21	50.13	15.65	47.04	13.01	53.26	13.11	47.94
0.12	14.29	59.77	15.30	50.34	15.50	54.69	17.07	51.31	14.19	58.10	14.31	52.30
0.13	15.48	64.75	16.58	54.53	16.79	59.25	18.49	55.59	15.38	62.94	15.50	56.66
0.14	16.68	69.74	17.85	58.73	18.09	63.80	19.91	59.86	16.56	67.78	16.69	61.02
0.15	17.87	74.72	19.13	62.92	19.38	68.36	21.34	64.14	17.74	72.62	17.88	65.38
0.16	19.06	79.70	20.40	67.12	20.67	72.92	22.76	68.42	18.92	77.46	19.08	69.73
0.17	20.25	84.68	21.68	71.31	21.96	77.48	24.18	72.69	20.11	82.30	20.27	74.09
0.18	21.44	89.66	22.95	75.51	23.25	82.03	25.60	76.97	21.29	87.15	21.46	78.45
0.19	22.63	94.64	24.23	79.70	24.54	86.59	27.03	81.24	22.47	91.99	22.65	82.81
0.20	23.82	99.62	25.50	83.90	25.84	91.15	28.45	85.52	23.65	96.83	23.84	87.17
0.21	25.01	104.60	26.78	88.09	27.13	95.71	29.87	89.80	24.84	101.67	25.04	91.53
0.22	26.20	109.58	28.05	92.29	28.42	100.26	31.29	94.07	26.02	106.51	26.23	95.88
0.23	27.40	114.57	29.33	96.48	29.71	104.82	32.72	98.35	27.20	111.35	27.42	100.24
0.24	28.59	119.55	30.60	100.68	31.00	109.38	34.14	102.62	28.38	116.19	28.61	104.60
0.25	29.78	124.53	31.88	104.87	32.30	113.94	35.56	106.90	29.57	121.04	29.81	108.96
0.26	30.97	129.51	33.16	109.06	33.59	118.49	36.98	111.18	30.75	125.88	31.00	113.32
0.27	32.16	134.49	34.43	113.26	34.88	123.05	38.40	115.45	31.93	130.72	32.19	117.68
0.28	33.35	139.47	35.71	117.45	36.17	127.61	39.83	119.73	33.12	135.56	33.38	122.04
0.29	34.54	144.45	36.98	121.65	37.46	132.16	41.25	124.00	34.30	140.40	34.57	126.39
0.30	35.73	149.43	38.26	125.84	38.75	136.72	42.67	128.28	35.48	145.24	35.77	130.75
0.31	36.92	154.41	39.53	130.04	40.05	141.28	44.09	132.56	36.66	150.08	36.96	135.11
0.32	38.12	159.40	40.81	134.23	41.34	145.84	45.52	136.83	37.85	154.92	38.15	139.47
0.33	39.31	164.38	42.08	138.43	42.63	150.39	46.94	141.11	39.03	159.77	39.34	143.83
0.34	40.50	169.36	43.36	142.62	43.92	154.95	48.36	145.38	40.21	164.61	40.53	148.19
0.35	41.69	174.34	44.63	146.82	45.21	159.51	49.78	149.66	41.39	169.45	41.73	152.54
0.36	42.88	179.32	45.91	151.01	46.50	164.07	51.21	153.94	42.58	174.29	42.92	156.90
0.37	44.07	184.30	47.18	155.21	47.80	168.62	52.63	158.21	43.76	179.13	44.11	161.26
0.38	45.26	189.28	48.46	159.40	49.09	173.18	54.05	162.49	44.94	183.97	45.30	165.62
0.39	46.45	194.26	49.73	163.60	50.38	177.74	55.47	166.76	46.13	188.81	46.50	169.98
0.40	47.64	199.24	51.01	167.79	51.67	182.30	56.90	171.04	47.31	193.66	47.69	174.34
0.41	48.84	204.23	52.28	171.99	52.96	186.85	58.32	175.32	48.49	198.50	48.88	178.69
0.42	50.03	209.21	53.56	176.18	54.26	191.41	59.74	179.59	49.67	203.34	50.07	183.05

Conductivity (μs/cm)	TOC Range (ppb) for Block-1 (Inlet)		TOC Range (ppb) for Block-1 (Outlet)		TOC Range (ppb) for Block-2 (Inlet)		TOC Range (ppb) for Block-2 (Outlet)		TOC Range (ppb) for Block-3 (Inlet)		TOC Range (ppb) for Block-3 (Outlet)	
	From	To	From	To	From	To	From	To	From	To	From	To
0.43	51.22	214.19	54.83	180.38	55.55	195.97	61.16	183.87	50.86	208.18	51.26	187.41
0.44	52.41	219.17	56.11	184.57	56.84	200.53	62.59	188.14	52.04	213.02	52.46	191.77
0.45	53.60	224.15	57.38	188.77	58.13	205.08	64.01	192.42	53.22	217.86	53.65	196.13
0.46	54.79	229.13	58.66	192.96	59.42	209.64	65.43	196.70	54.40	222.70	54.84	200.49
0.47	55.98	234.11	59.93	197.16	60.71	214.20	66.85	200.97	55.59	227.55	56.03	204.84
0.48	57.17	239.09	61.21	201.35	62.01	218.76	68.28	205.25	56.77	232.39	57.23	209.20
0.49	58.36	244.07	62.48	205.55	63.30	223.31	69.70	209.52	57.95	237.23	58.42	213.56
0.50	59.56	249.06	63.76	209.74	64.59	227.87	71.12	213.80	59.14	242.07	59.61	217.92
0.51	60.75	254.04	65.04	213.93	65.88	232.43	72.54	218.08	60.32	246.91	60.80	222.28
0.52	61.94	259.02	66.31	218.13	67.17	236.98	73.96	222.35	61.50	251.75	61.99	226.64
0.53	63.13	264.00	67.59	222.32	68.47	241.54	75.39	226.63	62.68	256.59	63.19	231.00
0.54	64.32	268.98	68.86	226.52	69.76	246.10	76.81	230.90	63.87	261.44	64.38	235.35
0.55	65.51	273.96	70.14	230.71	71.05	250.66	78.23	235.18	65.05	266.28	65.57	239.71
0.56	66.70	278.94	71.41	234.91	72.34	255.21	79.65	239.46	66.23	271.12	66.76	244.07
0.57	67.89	283.92	72.69	239.10	73.63	259.77	81.08	243.73	67.41	275.96	67.96	248.43
0.58	69.08	288.90	73.96	243.30	74.92	264.33	82.50	248.01	68.60	280.80	69.15	252.79
0.59	70.27	293.88	75.24	247.49	76.22	268.89	83.92	252.28	69.78	285.64	70.34	257.15
0.60	71.47	298.87	76.51	251.69	77.51	273.44	85.34	256.56	70.96	290.48	71.53	261.50
0.61	72.66	303.85	77.79	255.88	78.80	278.00	86.77	260.84	72.14	295.33	72.72	265.86
0.62	73.85	308.83	79.06	260.08	80.09	282.56	88.19	265.11	73.33	300.17	73.92	270.22
0.63	75.04	313.81	80.34	264.27	81.38	287.12	89.61	269.39	74.51	305.01	75.11	274.58
0.64	76.23	318.79	81.61	268.47	82.68	291.67	91.03	273.66	75.69	309.85	76.30	278.94
0.65	77.42	323.77	82.89	272.66	83.97	296.23	92.46	277.94	76.88	314.69	77.49	283.30
0.66	78.61	328.75	84.16	276.86	85.26	300.79	93.88	282.22	78.06	319.53	78.69	287.65
0.67	79.80	333.73	85.44	281.05	86.55	305.35	95.30	286.49	79.24	324.37	79.88	292.01
0.68	80.99	338.71	86.71	285.25	87.84	309.90	96.72	290.77	80.42	329.22	81.07	296.37
0.69	82.19	343.70	87.99	289.44	89.13	314.46	98.15	295.04	81.61	334.06	82.26	300.73
0.70	83.38	348.68	89.26	293.64	90.43	319.02	99.57	299.32	82.79	338.90	83.45	305.09
0.71	84.57	353.66	90.54	297.83	91.72	323.58	100.99	303.60	83.97	343.74	84.65	309.45
0.72	85.76	358.64	91.81	302.03	93.01	328.13	102.41	307.87	85.15	348.58	85.84	313.80
0.73	86.95	363.62	93.09	306.22	94.30	332.69	103.84	312.15	86.34	353.42	87.03	318.16
0.74	88.14	368.60	94.36	310.42	95.59	337.25	105.26	316.42	87.52	358.26	88.22	322.52
0.75	89.33	373.58	95.64	314.61	96.89	341.81	106.68	320.70	88.70	363.11	89.42	326.88
0.76	90.52	378.56	96.92	318.80	98.18	346.36	108.10	324.98	89.89	367.95	90.61	331.24
0.77	91.71	383.54	98.19	323.00	99.47	350.92	109.52	329.25	91.07	372.79	91.80	335.60
0.78	92.91	388.53	99.47	327.19	100.76	355.48	110.95	333.53	92.25	377.63	92.99	339.96
0.79	94.10	393.51	100.74	331.39	102.05	360.03	112.37	337.80	93.43	382.47	94.18	344.31
0.80	95.29	398.49	102.02	335.58	103.34	364.59	113.79	342.08	94.62	387.31	95.38	348.67
0.81	96.48	403.47	103.29	339.78	104.64	369.15	115.21	346.36	95.80	392.15	96.57	353.03
0.82	97.67	408.45	104.57	343.97	105.93	373.71	116.64	350.63	96.98	396.99	97.76	357.39
0.83	98.86	413.43	105.84	348.17	107.22	378.26	118.06	354.91	98.16	401.84	98.95	361.75
0.84	100.05	418.41	107.12	352.36	108.51	382.82	119.48	359.18	99.35	406.68	100.14	366.11
0.85	101.24	423.39	108.39	356.56	109.80	387.38	120.90	363.46	100.53	411.52	101.34	370.46
0.86	102.43	428.37	109.67	360.75	111.09	391.94	122.33	367.74	101.71	416.36	102.53	374.82

Conductivity (µs/cm)	TOC Range (ppb) for Block-1 (Inlet)		TOC Range (ppb) for Block-1 (Outlet)		TOC Range (ppb) for Block-2 (Inlet)		TOC Range (ppb) for Block-2 (Outlet)		TOC Range (ppb) for Block-3 (Inlet)		TOC Range (ppb) for Block-3 (Outlet)	
	From	To	From	To	From	To	From	To	From	To	From	To
0.87	103.63	433.36	110.94	364.95	112.39	396.49	123.75	372.01	102.89	421.20	103.72	379.18
0.88	104.82	438.34	112.22	369.14	113.68	401.05	125.17	376.29	104.08	426.04	104.91	383.54
0.89	106.01	443.32	113.49	373.34	114.97	405.61	126.59	380.56	105.26	430.88	106.11	387.90
0.90	107.20	448.30	114.77	377.53	116.26	410.17	128.02	384.84	106.44	435.73	107.30	392.26
0.91	108.39	453.28	116.04	381.73	117.55	414.72	129.44	389.12	107.63	440.57	108.49	396.61
0.92	109.58	458.26	117.32	385.92	118.85	419.28	130.86	393.39	108.81	445.41	109.68	400.97
0.93	110.77	463.24	118.59	390.12	120.14	423.84	132.28	397.67	109.99	450.25	110.87	405.33
0.94	111.96	468.22	119.87	394.31	121.43	428.40	133.71	401.94	111.17	455.09	112.07	409.69
0.95	113.15	473.20	121.14	398.51	122.72	432.95	135.13	406.22	112.36	459.93	113.26	414.05
0.96	114.35	478.19	122.42	402.70	124.01	437.51	136.55	410.50	113.54	464.77	114.45	418.41
0.97	115.54	483.17	123.69	406.90	125.30	442.07	137.97	414.77	114.72	469.62	115.64	422.76
0.98	116.73	488.15	124.97	411.09	126.60	446.63	139.40	419.05	115.90	474.46	116.84	427.12
0.99	117.92	493.13	126.24	415.29	127.89	451.18	140.82	423.32	117.09	479.30	118.03	431.48
1.00	119.11	498.11	127.52	419.48	129.18	455.74	142.24	427.60	118.27	484.14	119.22	435.84
1.01	120.30	***503.09***	128.80	423.67	130.47	460.30	143.66	431.88	119.45	488.98	120.41	440.20
1.02	121.49	***508.07***	130.07	427.87	131.76	464.85	145.08	436.15	120.64	493.82	121.60	444.56
1.03	122.68	***513.05***	131.35	432.06	133.06	469.41	146.51	440.43	121.82	498.66	122.80	448.92
1.04	123.87	***518.03***	132.62	436.26	134.35	473.97	147.93	444.70	123.00	***503.51***	123.99	453.27
1.05	125.07	***523.02***	133.90	440.45	135.64	478.53	149.35	448.98	124.18	***508.35***	125.18	457.63
1.06	126.26	***528.00***	135.17	444.65	136.93	483.08	150.77	453.26	125.37	***513.19***	126.37	461.99
1.07	127.45	***532.98***	136.45	448.84	138.22	487.64	152.20	457.53	126.55	***518.03***	127.57	466.35
1.08	128.64	***537.96***	137.72	453.04	139.51	492.20	153.62	461.81	127.73	***522.87***	128.76	470.71
1.09	129.83	***542.94***	139.00	457.23	140.81	496.76	155.04	466.08	128.91	***527.71***	129.95	475.07
1.10	131.02	***547.92***	140.27	461.43	142.10	***501.31***	156.46	470.36	130.10	***532.55***	131.14	479.42
1.11	132.21	***552.90***	141.55	465.62	143.39	***505.87***	157.89	474.64	131.28	***537.40***	132.33	483.78
1.12	133.40	***557.88***	142.82	469.82	144.68	***510.43***	159.31	478.91	132.46	***542.24***	133.53	488.14
1.13	134.59	***562.86***	144.10	474.01	145.97	***514.99***	160.73	483.19	133.65	***547.08***	134.72	492.50
1.14	135.79	***567.85***	145.37	478.21	147.27	***519.54***	162.15	487.46	134.83	***551.92***	135.91	496.86
1.15	136.98	***572.83***	146.65	482.40	148.56	***524.10***	163.58	491.74	136.01	***556.76***	137.10	***501.22***
1.16	138.17	***577.81***	147.92	486.60	149.85	***528.66***	165.00	496.02	137.19	***561.60***	138.30	***505.57***
1.17	139.36	***582.79***	149.20	490.79	151.14	***533.22***	166.42	***500.29***	138.38	***566.44***	139.49	***509.93***
1.18	140.55	***587.77***	150.47	494.99	152.43	***537.77***	167.84	***504.57***	139.56	***571.29***	140.68	***514.29***
1.19	141.74	***592.75***	151.75	499.18	153.72	***542.33***	169.27	***508.84***	140.74	***576.13***	141.87	***518.65***
1.20	142.93	***597.73***	153.02	***503.38***	155.02	***546.89***	170.69	***513.12***	141.92	***580.97***	143.06	***523.01***
1.21	144.12	***602.71***	154.30	***507.57***	156.31	***551.45***	172.11	***517.40***	143.11	***585.81***	144.26	***527.37***
1.22	145.31	***607.69***	155.57	***511.77***	157.60	***556.00***	173.53	***521.67***	144.29	***590.65***	145.45	***531.72***
1.23	146.51	***612.68***	156.85	***515.96***	158.89	***560.56***	174.96	***525.95***	145.47	***595.49***	146.64	***536.08***
1.24	147.70	***617.66***	158.12	***520.16***	160.18	***565.12***	176.38	***530.22***	146.65	***600.33***	147.83	***540.44***
1.25	148.89	***622.64***	159.40	***524.35***	161.48	***569.68***	177.80	***534.50***	147.84	***605.18***	149.03	***544.80***
1.26	150.08	***627.62***	160.68	***528.54***	162.77	***574.23***	179.22	***538.78***	149.02	***610.02***	150.22	***549.16***
1.27	151.27	***632.60***	161.95	***532.74***	164.06	***578.79***	180.64	***543.05***	150.20	***614.86***	151.41	***553.52***
1.28	152.46	***637.58***	163.23	***536.93***	165.35	***583.35***	182.07	***547.33***	151.39	***619.70***	152.60	***557.88***
1.29	153.65	***642.56***	164.50	***541.13***	166.64	***587.90***	183.49	***551.60***	152.57	***624.54***	153.79	***562.23***
1.30	154.84	***647.54***	165.78	***545.32***	167.93	***592.46***	184.91	***555.88***	153.75	***629.38***	154.99	***566.59***

Afterwards, all obtained values of TOC were cross verified against established range of TOC for respective block / loop and found that all values are met to the acceptance criteria.

Based on the data, it can be observed that probability of TOC value getting in higher range or out of the specification value (i.e. > 500 ppb) might be arise even the conductivity is passing their specification criteria (≤ 1.3 μs/cm) because of various other factors impacting the conductivity value. Hence, TOC is more important and critical factor for a water system.

Moreover, the TOC range w.r.t. conductivity values can be defined based on the trends observed at specific water systems and these are more accurately illustrating the actual TOC results and can be hypothecated based on the online conductivity results of a water system.

However, the data indicates that TOC might get out of the specification limit at conductivity of 1.01 for Block-1 inlet and 1.2 for Block-1 outlet. Similarly, TOC might get out of the specification limit at conductivity of 1.10 for Block-2 outlet and at 1.17 for Block-2 outlet. Likewise, TOC might get out of the specification limit at conductivity of 1.04 for Block-3 outlet and at 1.15 for Block-3 outlet.

Hence, these conductivity values can be considered as alert level alarming value for each block / return loop sampling point. The established TOC range w.r.t. conductivity values are verified during the routine sampling and data is observed within the defined range. This illustrates that the given range (based on the statistical calculation) is effective and can be considered as an alternative to the online TOC checker for small volume industries.

4. Conclusions

Physicochemical parameters of water for injection manufactured at a pharmaceutical industry for sterile drug product processing purposes were reported. The results revealed that probability of TOC value getting in higher range or out of the specification value (i.e. > 500 ppb) might be arise even the conductivity is passing their specification criteria (≤ 1.3 μs/cm) because of various other factors impacting the conductivity value. Hence, TOC is more important and critical factor for a water system.

Moreover, the TOC range w.r.t. conductivity values can be defined based on the trends observed at specific water system and these are more accurately illustrating the actual TOC results and also can be hypothecated based on the online conductivity results of a water system. Hence, the conductivity values can be considered a trigger point for rise in TOC levels of the WFI line i.e. return loop in all water systems available at site. Further, the given study can be considered as an alternate of the online TOC checker for small volume industries.

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ВИЗНАЧЕННЯ КОРЕЛЯЦІЇ МІЖ ЗНАЧЕННЯМИ ЗАГАЛЬНОГО ОРГАНІЧНОГО КАРБОНУ ТА ПРОВІДНОСТІ ЛІНІЇ ВОДИ ДЛЯ ІН'ЄКЦІЙ ТА ВСТАНОВЛЕННЯ ДІАПАЗОНУ ЗАГАЛЬНОГО ОРГАНІЧНОГО КАРБОНУ ДЛЯ ПЕВНОГО ЗНАЧЕННЯ ПРОВІДНОСТІ НА ЛІНІЇ/КОНТУРІ ВОДИ ДЛЯ ІН'ЄКЦІЙ

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У даній статті досліджувався взаємозв'язок між значеннями провідності та вмісту загального органічного карбону (ЗОК) у системах води для ін'єкцій на фармацевтичному виробництві в Уттаракханді. Вимірювання проводилися на вході та виході зворотних контурів води для ін'єкцій у трьох окремих блоках протягом 90-денного періоду з жовтня 2024 року по січень 2025 року. Результати дослідження показали, що кожен блок потребує окремого діапазону загального органічного карбону, оскільки рівні загального органічного карбону, хоча загалом корелюють з провідністю, також залежать від таких факторів, як довжина трубопроводу, діаметр та кількість точок споживання. Важливо, що значення загального органічного карбону можуть перевищувати специфікації, навіть якщо провідність знаходиться в допустимих межах, що підкреслює критичну необхідність моніторингу загального органічного карбону для кожного блоку. Крім того, діапазон загального органічного карбону відносно значень провідності можна визначити на основі тенденцій, що спостерігаються в конкретних системах водопостачання, і вони точніше ілюструють фактичні значення загального органічного карбону, а також можуть бути гіпотетично обґрунтовані на основі результатів онлайн-вимірювання провідності системи водопостачання або системи розподілу води для ін'єкцій, що використовується у фармацевтичній промисловості. В дослідженні зроблено висновок, що визначення діапазонів загального органічного карбону відносно тенденцій провідності покращує моніторинг якості води для фармацевтичних процесів та забезпечує точний контроль органічного забруднення.

Ключові слова: *фармацевтичне виробництво, загальний органічний карбон, вода для ін'єкцій, якість води.*