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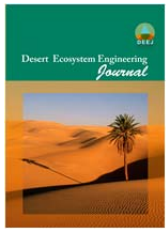

Effects of Land Use Changes and Human Activities on the Temporal and Spatial Variations of Water Quality in the Aras Border River

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Abstract

The increase in human population, expansion of residential areas, and change in land use are putting pressure on water resources. Human activities such as industrial and urban development, farming, combustion of fossil fuels, and alterations to stream-channels impact both quality and quantity of water. The main goal of this study was to examine the impact of land use changes on the temporal and spatial variation of water quality in the Aras River. To achieve this, changes in land use within the Aras River watershed were analyzed for the years 1995, 2001, 2010 and 2016, using MSS, ETM and OLI images of Landsat satellites. The non-parametric Mann-Kendall test was utilized to assess trend in changes over the study period. Results showed that, the amount of rangeland decreased by 15.21% from 1995 to 2016, while agricultural land and urban areas increased by 14.33% and 0.87% respectively. Various water quality parameters, such as BOD, TDS, EC, nitrate, phosphate and sulfate exhibited an increasing trend, with a more pronounced increase observed from 2010 to 2016. All qualitative parameters showed a positive upward trend. The changes in land use had significant impact on the quality of the Aras water. It is crucial to implement measures to prevent pollution of the Aras River in order to avoid future issues.

Keywords: Quality parameters, Water Pollution, Trend, Man-Kendall test, Aras River.

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1. Introduction

The increase in the human population and consequently, the increase in human activities such as industrial and urban development, farming, combustion of fossil fuels, and stream-channel alteration should affect both water quality and quantity (Zhong et al., 2018; Wei et al., 2020). Conservation and optimal use of water resources are principal factors in sustainable development. Due to climate and socio-economic changes, water resources are in a critical stage, especially in arid and semi- arid area (Shoshtarian et al., 2018; Duffy et al., 2020). The reduction of fresh water and water pollution has become a key factor affecting sustainable development in many countries (Castillo et al., 2014). According to e reports from international organizations such as the World Water Council and UNESCO, on a global scale, the drinking water resources are very alarming in arid and semi-arid areas (Palamuleni et al., 2011). The World Water Council predicts that by 2050, most countries in the world will face a water crisis. Moreover, the reduction of the freshwater quality is also an important challenge facing human life in recent years (Palamuleni et al., 2011; Mello et al., 2020; Nicholas et al., 2020; Singh et al., 2020; Mwaijengo et al., 2019; Slama and Sebei, 2020). The degree and scale of water hazards have also changed with increasing population and pressure on natural resources, (Du et al., 2013). The study of the quantity and quality of surface and groundwater due to land use and climate change, urbanization, economic change, and migration, and their trend changes is necessary for sustainable management of natural resources (Hong Hanh, 2017; Nguyen et al., 2018; Oliveira Serrão et al., 2020).

Land use change is a fundamental parameter to determine the quantity and quality of changes in the natural environment and human activities (Gao et al., 2016; Lian et al., 2017; Mendoza et al., 2011; Turner et al., 2007; Wu et al., 2016). Many efforts have been made by researchers to study the structural features of land use change that should affect water quality in river basins (He et al., 2017; Wu et al., 2012; Zhang et al., 2016; Cao et al., 2014; Deng and Zheng, 2010; Kozak et al., 2017; Li and Li, 2017; Shersta and Lal, 2010). The effects of land use change on the quality of water resources have been studied by many researchers around the world (e.g., Andard et al. 2008; Castillo et al. 2014; Mohammad Adnan et al. 2016; Gao et al., 2019; Zengliang et al. 2020, Li et al., 2013; Itxaso and anz-Sánchez, 2020; Nicholas et al., 2020; Mello et al., 2020). The results of studies in the different parts of the world have shown that the effect of land use changes varies depending on the conditions of each region.

The Aras River is a relatively watery and roaring river that originates from the Bingol Mountains in the Anatolian region of Turkey and finally flows into the Caspian Sea after joining the Kora River in the Republic of Azerbaijan. Significant development of agricultural, industrial and urbanization activities has occurred in the river environs zone. Moreover, all towns and villages in the region get their drinking water from this river. Various pollutants have been added to the river system. In some cases, municipal and industrial wastewater, as well as agricultural wastewater enter the river directly, without any treatment (Pahlavani et al., 2015). The main aims of this study were 1) to investigate the trend of land use change, 2) to investigate the trend of spatial changes in water quality; and 3) to investigate the trend of temporal changes in water quality of the Aras River due to land use changes.

2. Materials and methods

2.1. Study Area

The Aras River (40° 1′ 6.24″ N, 48° 27′ 12.6″ E), flows along the borders of Turkey (15.1%), Azerbaijan (31.5%), Iran (19.5%), Georgia (18.2%), and Armenia (15.7%). This river originates in eastern Turkey. It spans 1070 km before reaching the Caspian Sea, with 475 km forming is the border between Iran, Armenia and Azerbaijan (Figure 1). The average annual precipitation in the Aras basin is approximately 565 mm, with an average temperature of 9 °C. The river passes through Ardabil province in Iran near the Mill and Moghan dam, continues through the northeastern part of Parsabad Moghan city, in Azarbajan merges with Korea river, and eventually empties into the Caspian Sea. The study area focused on the section of the river within Ardabil province.

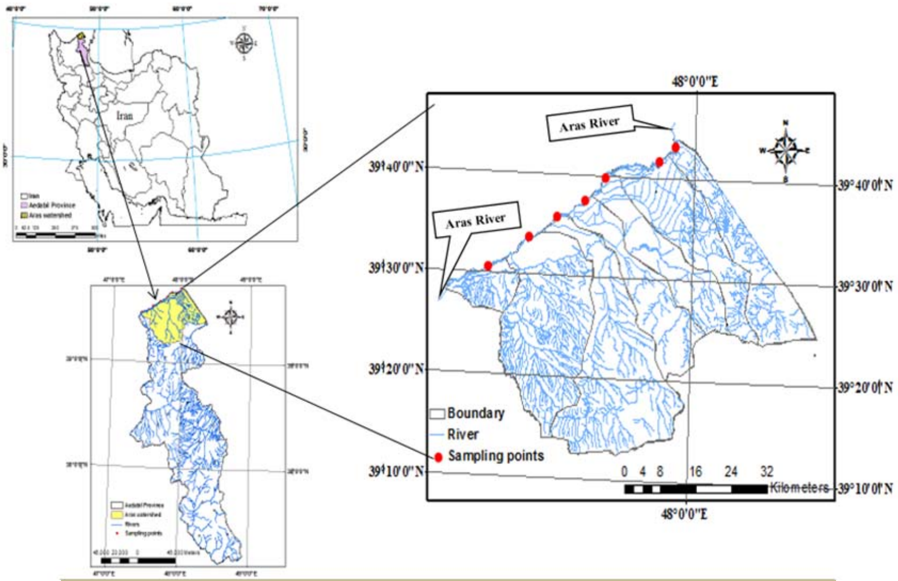

Figure (1): Geographical location of Aras watershed and Aras River

2.2. Research methodology

This study was conducted in four stages: data collection and preparation of necessary maps, analysis of temporal changes in water quality, examination of spatial changes in water quality, and evaluation of trends in water quality changes using statistical tests.

2.2.1. Data collection and preparation of required maps

In this study, Landsat satellite images were utilized to create land use maps through remote sensing techniques (Table 1).

Table (1): Details of used satellite images

Date	Solar History	Satellite	Sensors	Row	Transition
1995	1995.May.10	Landsat 5	MSS	37	166
2000	2000.June.10	Landsat 5	ETM	37	166
2010	2010.May.10	Landsat 7	OLI	37	166
2016	2016.May.10	Landsat 8	OLI	37	166

Digital sensor data is imported to ENVI software to assess data quality. Geometric correction of the satellite images was conducted using 110 ground control points. To enhance the image quality, the contrast was adjusted. Contrast improvement involves expanding the finite range of spectral values in an image to a wider range.

Supervised Classification method was used to cluster data based on spectral similarity and statistical properties. User classes (such as agriculture, rangeland, and residential) areas were randomly sampled and their GPS coordinates were recorded. Geometric correction of satellite images was performed with the removal of points with an error of one pixel or more. Ultimately, 85 control points were used for the final correction, resulting in an average error of 0.735 pixels, which is deemed acceptable.

2-2-2. Water quality Assessment of the Aras River

To investigate temporal changes in the water quality of the Aras River, water quality data (BOD, COD, DO, EC, TDS, Nitrate, Phosphate, Sulfate) were analyzed (from1995 to 2016). The Shapiro-Wilk statistical test (Eq.1) was used to assess the normality of the data (Dalal and Wilkinson, 1986; Royston, 1982).

$$\mathbf{W} = \frac{[\sum_{i=1}^{n} a_i X_i]^2}{\sum_{i=1}^{n} (X_i - \bar{X})^2} \quad (1)$$

Where xi represents the ordered random sample values, n is the total number of observations, and a_i are constants generated from the co-variances, variances and means of the sample (size n) from a normally distributed sample. In this method, if the value of P obtained for the Shapiro-Wilk parameter (W) is greater than 0.05, the data series follows a 95% confidence level of the normal distribution. To examine the change in data trend, the non-parametric Mann-Kendall test was used due to the non-normality of the data. For this purpose, data is arranged in order of time, then each data point is compared with all subsequent data points (Eq.2).

$$S = \sum_{i+1}^{n-1} \sum_{j=i+1}^{n} sign(X_i - X_j)$$

$$\boldsymbol{sign(\theta)} = \begin{bmatrix} \mathbf{1} & \boldsymbol{if} & \boldsymbol{\theta > 0} \\ \mathbf{0} & \boldsymbol{if} & \boldsymbol{\theta = 0} \\ \mathbf{-1} & \boldsymbol{if} & \boldsymbol{\theta < 0} \end{bmatrix} \quad (2)$$

For independent random variables with a uniform distribution without knots (two or more data with equal numerical values arranged in a series), the mean and variance (S) were calculated (Eq.3).

$$E(S) = 0 \quad Var(S) = \frac{n(n1)(2n+5)}{18} = \sigma^2 \quad (3)$$

When there is a node in the data series, the value of variance is calculated (Eq.4):

$$S = \frac{n(n-1)(2n-5)\sum_{i+1}^{n} t_i(i)(i-1)(2i-5)}{18} \quad (4)$$

Where t_i represents the number of nodes with factor i. If the number of data in a series is more than 10, S follow the normal distribution and the statistical standard value (Z_S) shoud be estimated (Eq.5).

$$\boldsymbol{Z_s} = \begin{cases} \dfrac{\boldsymbol{s-1}}{\sqrt{\boldsymbol{var(s)}}} & \boldsymbol{if} \quad \boldsymbol{s > 0} \\ \mathbf{0} & \boldsymbol{if} \quad \boldsymbol{s = 0} \\ \dfrac{\boldsymbol{s+1}}{\sqrt{\boldsymbol{var(s)}}} & \boldsymbol{if} \quad \boldsymbol{s < 0} \end{cases} \quad (5)$$

Therefore, in a two-way test, if the absolute value of Zs is greater than or equal to Z in the standard table, the null hypothesis will be rejected. This results in a statistically significant trend being reported at a confidence level. To analyze the trend of data in seasonal and annual data series, the data trend will be considered significant when the absolute values of Z obtained from the Mann-Kendall test are greater than 1.96 (P<0.05). A higher level of significant will be reached when Z is greater than 2.56 (P<0.99).

To investigate the relationship between land use changes and change in data quality, the spatial and temporal trend of water quality data and land use changes were compared using the LSD statistical test in R software.

3. Results and Discussion

3.1. Land use changes

Land use maps for the years 1995, 2000, 2010 and 2016 were prepared using satellite images and field survey (Figure 2). Based on the results, in all study periods, the lowest level of land is occupied by residential land use, but the rate of urban land use changes was more significant. The residential area tripled in 2016 compared to 1995. Rangeland occupied 64.25 % of the study area until 1995; however, since 2016, rangelands area decreased with an increase in agricultural lands (Table 2). Agricultural and residential land area has continuously increased in the study period (Figure 3). Agricultural land expansion occurred in the Aras watershed due to the fertility of its lands, abundant flat lands and the existence of permanent water resources (Aras River). Consequently, migration increased from surrounding cities and provinces to this basin, leading to the expansion of residential lands.

Table (2): Land use classes in the studied years

Land use type	1995		2000		2010		2016	
	Area (hectare)	percent	Area (hectare)	percent	Area (hectare)	percent	Area (hectare)	percent
Agriculture	80313.57	35.29	98204.13	43.15	100139.67	44	112935.44	50.62
Residential	1059.3	0.47	1418.13	0.62	1548.81	0.68	30.49	1.34
Rangeland	146227.77	64.25	127978.38	56.23	125912.16	55.32	111615.35	48.04
Total	227600.64	100	227600.64	100	227600.64	100	227600.64	100

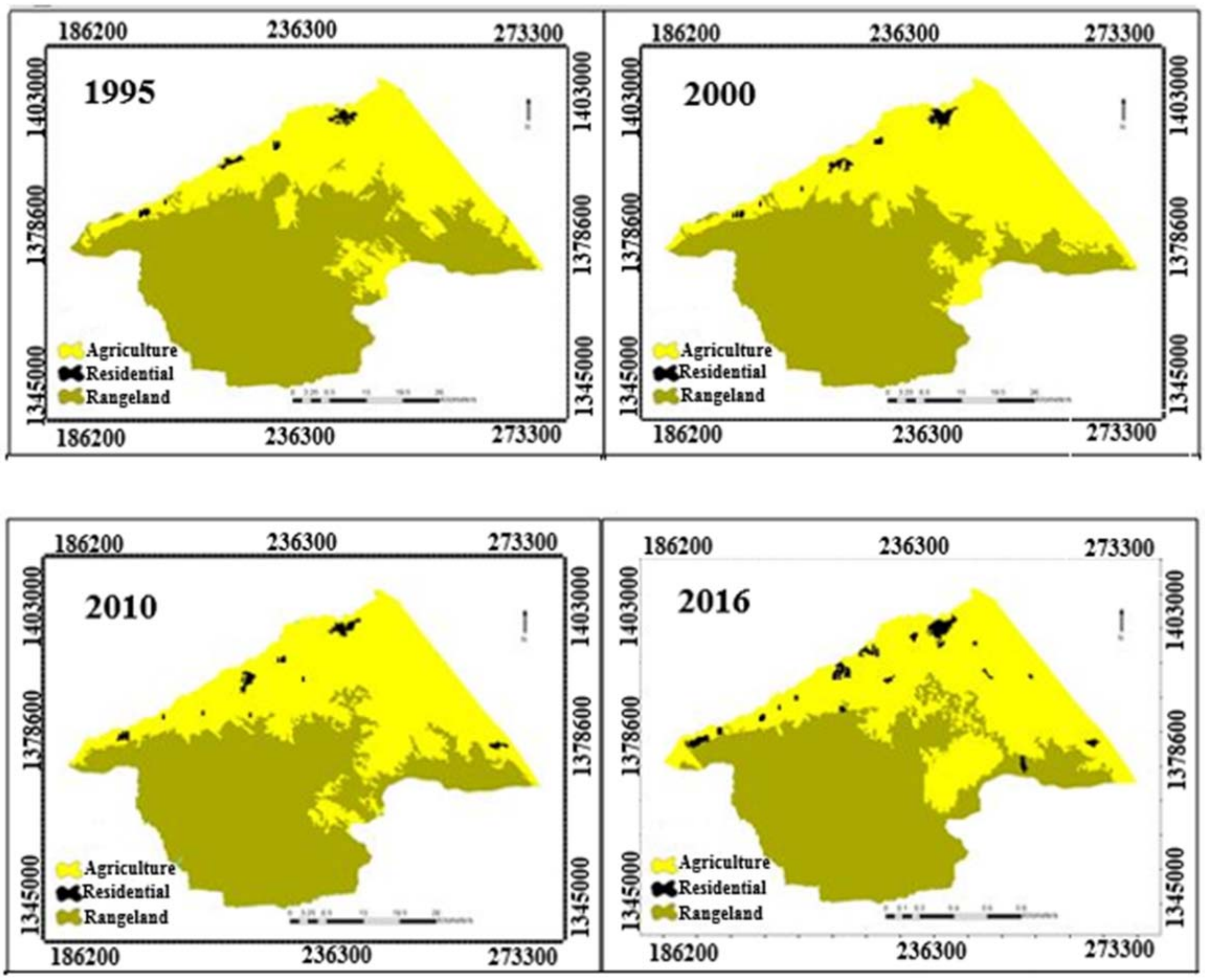

Figure (2): Land use change of the study area (1995-2000-2010-2016)

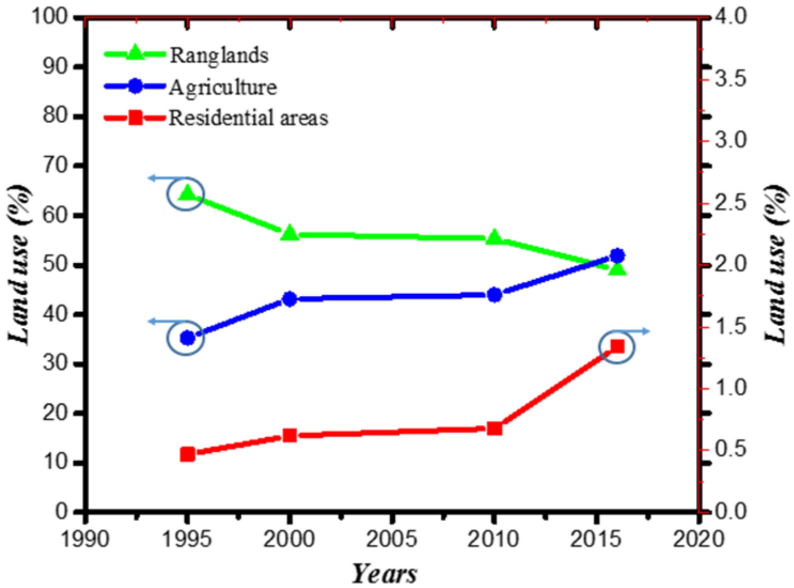

Figure (3): Land use changes trend in (2000 to 2016)

3.2. Water quality

According to the results, water quality of the Aras River decreased continuously from 1995 to 2016. Changes in water quality parameters were more intense from 2000 to 2010 compared to the previous period. However, water quality sharply decreased in the last 6 years (Figure 4). These changes have been consistent with land use changes and the increasing agricultural lands.

In the study area, most agricultural effluents, a lot of domestic and industrial sewage and some urban wastewater discharge directly into the river. Population growth, urbanization, industrial growth and agricultural activities have a significant impact on the quantity and quality of water resources (Sivakumar and Ghosh, 2016; Mundal et al., 2018; Wigam and Jordan, 2003; Mits et al., 2012; Saloja and Garg, 2017).

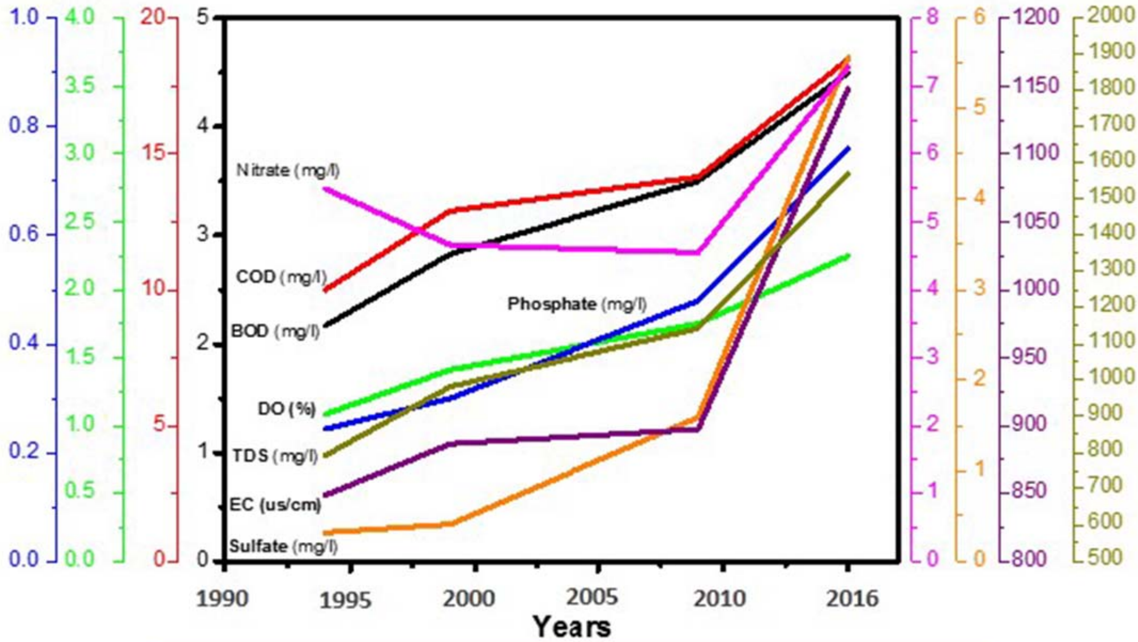

Figure (4): Change of the water quality parameters in the statistical years

Table (3) shows the monthly changes in water quality parameters between 2000 and 2016. The results showed an increasing trend in BOD, COD and DO parameters during the study period. According to the results, the average amount of the BOD and COD showed an increasing trend over the years. The average annual BOD increased from 2.17 in 1995 to 2.8 in 2000, 3.5 in 2000 and 4.5 in 2016 (207%), indicating a sharp increase in organic pollutants. Table 4 shows the monthly changes in water quality parameters of the Aras River between 2000 and 2016. According to the results, maximum BOD was observed in the spring and early summer, when the amount of dissolved oxygen was minimized. In all years, maximum Do and minimum organic matter (BOD) were recorded during winter. The amount of dissolved oxygen (DO) decreased with an increasing in organic matter leading to higher oxygen consumption by aerobic bacteria. Consequently, a relative decrease in the amount of dissolved oxygen is observed in the statistical years. The results indicate an increasing trend in EC and TDS during the study period. TDS is an important factor in determining the sustainability of water quality for various water supply in terms of drinking, agriculture and industry. According to the results, a sharply increase in TDS (98.45%) was observed for the study years. An increasing trend was also observed in nitrate, phosphate (32.67%) and sulfate (216%). These changes have led to a decrease in the water quality of the Aras River. The deterioration of water resources due to human activities and change in land use has been extensively studied by various researchers (Hu et al., 2003; Andard et al., 2008; Gao et al., 2019; Zengliang et al., 2020; Li et al., 2020; Itxaso and anz-Sánchez, 2020; Nicholas et al., 2020; Mello et al., 2020).

Table (4): Monthly changes of water quality parameters of the Aras River in the statistical years

Month	BOD				COD				DO				EC			
	1995	**2000**	**2010**	**2016**	**1995**	**2000**	**2010**	**2016**	**1995**	**2000**	**2010**	**2016**	**1995**	**2000**	**2010**	**2016**
November	2	3	2	3.00	9	8	10	18	9	8.9	7.54	7.8	978	991	1006	1099
December	1	2	3	2.00	8	10	12	18	8.9	8.7	8.4	8.1	818	1082	975	1406
January	2	3	1	2.00	8	13	14	29	8.6	8.9	7.9	6.6	999	1017	1039	1159
February	1	2	2	3.00	10	14	15	18	8.8	8.15	7.59	8.1	984	1002	1024	1186
March	2	1	2	3.00	9	14	15	20	8.9	8	6.3	6.1	950	968	990	1208
April	2	2	5	6.00	9	11	10	12	7.8	7.2	7.14	7.2	847	865	887	1040
May	2	3	5	6.00	7	9	11	12	8	7.5	6.5	7.5	721	739	761	850
June	3	3	4	7.00	13	16	18	22	7.4	7.3	6.4	6.3	557	575	597	843
July	2	4	5	6.00	12	16	18	24	5.3	4.9	4.2	4.9	788	806	828	874
August	3	3	4	5.00	12	13	15	15	5	5.5	4	3.5	792	810	832	1140
September	3	4	4	4.00	13	14	15	16	7.4	7.2	6.6	4.2	797	815	837	1232
October	3	4	5	7.00	10	17	17	18	7.7	7.4	5.8	6.7	950	968	990	1740
month	**TDS**				**Nitrate**				**Phosphate**				**Sulfate**			
	1995	**2000**	**2010**	**2016**	**1995**	**2000**	**2010**	**2016**	**1995**	**2000**	**2010**	**2016**	**1995**	**2000**	**2010**	**2016**
November	۹۷۰	925	819	1451	8.08	9.5	10.5	8.86	0.51	0.53	0.68	0.77	0.2	0.3	2.19	8.08
December	994	1011	1094	1452	8.95	7.6	8.3	13.4	0.58	0.66	0.76	0.92	0.1	0.33	2.14	8.95
January	792	893	854	1308	10.56	8	14.2	14.6	0.21	0.14	0.22	0.39	0.13	0.6	1.13	8.56
February	994	1023	1110	1520	4.07	1.2	2.6	4.9	0.09	0.16	0.24	0.44	0.13	0.65	1.15	4.07
March	685	1076	1102	1505	4.66	1.23	3.5	5.2	0.14	0.18	0.24	0.43	0.1	0.63	1.2	4.66
April	685	998	1093	1683	4.208	1.3	1.6	5.2	0.20	0.22	0.33	0.85	0.07	0.6	1	4.208
May	572	853	1121	1628	3.16	1.4	2.2	4.3	0.09	0.19	0.51	1.20	0.16	0.22	1.85	5.16
June	685	745	1020	1360	4	1.2	0.3	4.8	0.08	0.15	1.00	1.25	0.43	0.13	1.96	5
July	540	990	1300	1680	3.906	1.9	3.3	4.8	0.15	0.16	0.30	0.85	0.61	0.14	1.73	3.906
August	582	1008	1369	1588	3.74	6.9	0.2	4.6	0.25	0.35	0.33	0.66	0.65	0.09	1.67	3.74
September	755	1005	1352	1782	5.28	7.9	3.8	8.6	0.31	0.53	0.60	0.73	0.6	0.1	1.71	5.28
October	1247	1256	1485	1898	5.23	7.8	4.1	8.2	0.31	0.38	0.65	0.67	0.62	1.1	1.41	5.23

A graphic study of the water quality conditions of The Aras River (Schuler diagram) also reveals that the levels of cations and anions have increased in recent years. Consequently, the water quality has gradually deteriorated, especially in terms of its suitability for drinking. According to the results of a double graph (based on the percentage values of major cations and anions in the water) the type of the water in the Aras River is primarily chloride (Figure 5). The quantity of solutes in the water is represented by the triangle on the right side of the graph confirming the high total dissolved (TDS) limit. Step diagrams illustrate that the predominant type of water in this river was Cl-Na + K, but since shifted to Mg-Na + K. in 2016

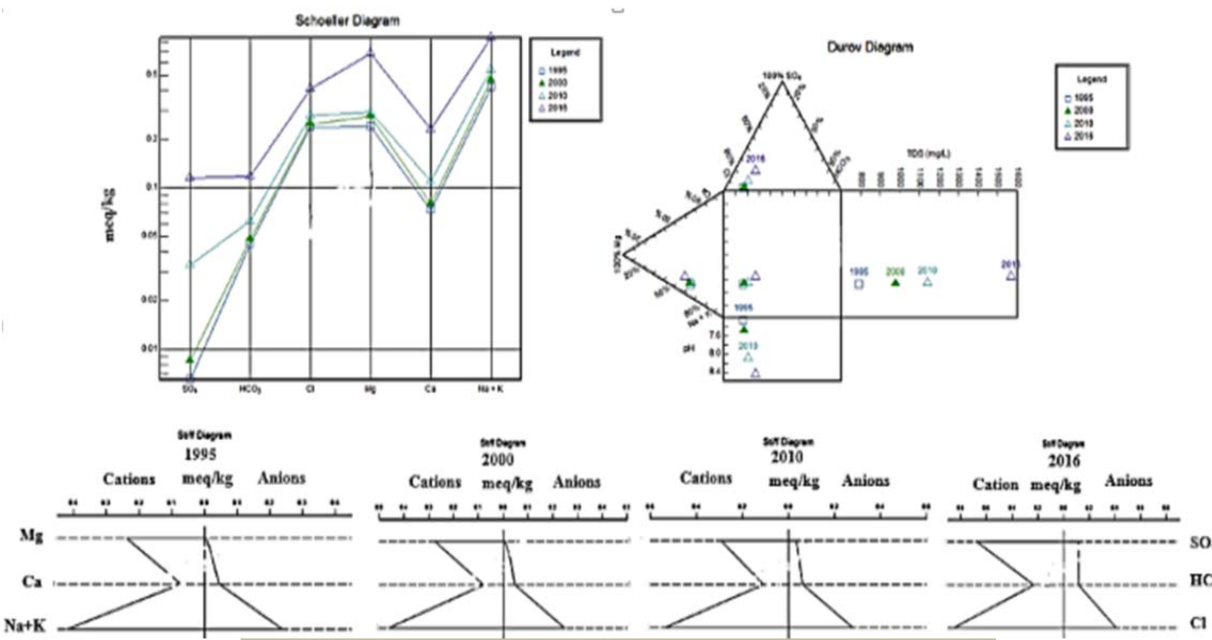

Figure (5): Graphic display of Aras River water quality conditions

3.3. Statistical analysis

The results of Shapiro-Wilk test indicate that the data did not flow a normal distribution (Table 5). So, the non-parametric Mann-Kendall test was used to analyze the trend in the data. The results show a significant increasing trend in all studied parameters at the 1% level (Table 5). The similar results were reported for seven stations in the Tahtal watershed of Turkey using non-parametric Mann-Kendall tests (Boyasiglu, 2008). The long-term changes in all statistical parameters tested in this study indicate an increase in the measured parameters and a decrease in water quality. Likely due to extensive land use changes, and direct transfer of agricultural industrial and urban wastewater to the river without treatment.

Table (5): Results of Shapiro-Wilk test (to determine normality of data) and Mann-Kendall test (to detect the trend of data)

parameter	Kendall test		Shapiro Wilk test	
	Tau	P_value	W	P
BOD	0.66	0.00	0.84	0.00
COD	0.66	0.00	0.82	0.00
DO	0.87	0.002	0.95	0.00
EC	0.94	0.00	0.89	0.002
TDS	0.63	0.00	0.78	0.00
Sulfate	0.68	0.00	0.87	0.0006
Nitrate	0.66	0.00	0.83	0.00
Phosphate	0.83	0.0003	0.77	0.00

3.4. Spatial changes in land use change and water quality

To study the spatial changes in land use and water quality in the Aras River, the watershed was divided into seven sub-basins based on current land uses. The water quality parameters measured at the outlet of each sub-basin (Figure 6). The results showed that agricultural land increased in all studied sub-basins from 1995 to 2016(Table 6). Maximum changes were related to sub-basin 4 with a 21% increase, while the lowest change was in sub-basin 3 with a 5.04% increase. Urban land use also increased with sub-basin 4 showing the highest increase (1.69%) and sub-basin 2 the lowest (0.06%). Rangeland area decreased in the whole basin with the highest decrease in sub-basin 4 (22.53%), and the lowest in sub-basin 2 (6.24%)

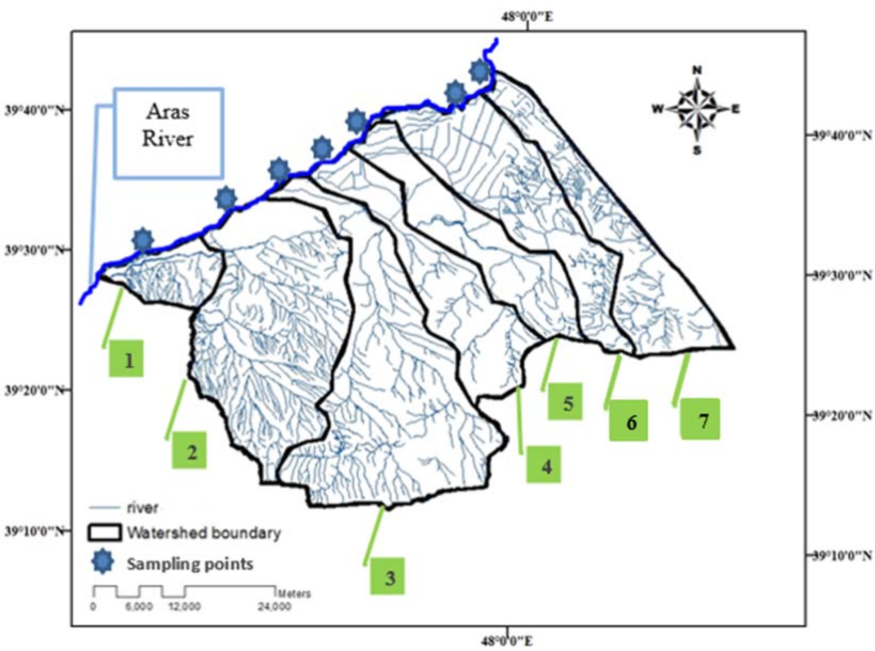

Figure (6): Location of sampling points

Table (6): Spatial changes of land use (%) in the studied time periods

	Sub1	sub2	sub3	sub4	sub5	sub6	sub7
Agriculture							
1995	32.12	12.25	19.41	34.41	75.11	73.19	86.25
2000	34.2	13.61	19.95	37.77	75.3	81.94	90.14
2010	40	15.1	22.19	41.2	78.18	85.63	95.98
2016	43.56	18.43	24.45	55.61	94.61	90.7	97.21
Residential							
1995	0.12	0.07	1.25	1.3	0.28	2.15	0.16
2000	0.18	0.07	1.26	1.32	0.28	2.46	0.44
2010	0.27	0.09	1.53	1.95	0.37	2.98	0.97
2016	0.84	0.13	2.12	2.63	0.95	3.84	0.78
Rangeland							
1995	67.76	87.68	79.39	64.29	24.61	24.66	13.59
2000	56.62	86.93	78.79	60.91	24.42	15.6	9.42
2010	59.73	81.55	76.28	56.85	21.45	11.39	3.05
2016	55.6	81.44	73.43	41.76	4.44	5.46	1.01

According to the results, the temporal changes of water quality parameters in all study periods were significant ($p < 0.05$), except for sulfate in all sub basins and phosphate for sub4, sub5 and sub6 (Table 7). Spatially, a significant change was observed for BOD, COD, DO, TDS, EC, nitrate, sulfate, and phosphate ($p < 0.01$) in all studied sub basins (Table 7).

Table (7): Temporal and spatial variations of water quality parameters

		Sub1	sub2	sub3	sub4	sub5	sub6	sub7	Compare Mean (Spatial)
BOD	1995	2.1	2.1	2.2	2.4	2.6	2.8	3	18.3^{**}
	2000	2.8	2.9	3	3.5	4	4	4.3	15.15^{**}
	2010	3.5	3.5	3.6	4.5	5.2	5.5	5.9	11.73^{**}
	2016	4.5	4.7	4.7	7.1	7.8	7.9	8.4	9.82^{**}
Compare Mean (Temporal)		6.29^{**}	6.4^{**}	4.35^{*}	4.44^{*}	4.9^{*}	4.59^{*}	4.64^{*}	-
COD	1995	10	10	10.3	10.5	10.5	10.5	10.7	101.52^{**}
	2000	12.95	13	13.2	13.4	13.5	13.6	13.8	112.16^{**}
	2010	14.15	14.2	14.35	14.35	14.5	14.5	14.65	216.69^{**}
	2016	19.2	19.2	19.4	19.5	19.5	19.6	19.8	239.52^{**}
Compare Mean		7.33^{**}	7.36^{**}	7.54^{**}	7.69^{**}	7.75^{**}	7.7^{**}	7.8^{**}	-
DO	1995	7.73	7.75	7.85	8.1	8.2	8.5	8.5	64.97^{**}
	2000	7.5	7.5	7.5	7.56	7.6	7.65	7.7	248.69^{**}
	2010	6.5	6.6	6.6	6.8	6.8	6.8	7	104.45^{**}
	2016	6.4	6.5	6.5	6.7	6.7	6.9	6.9	88.59^{**}
Compare Mean (Temporal)		20.6^{**}	1.78^{**}	21.34^{**}	22^{**}	20.66^{**}	19.92^{**}	20.3^{**}	-
EC	1995	848.4	850	855	856	856	860	869	232.29^{**}
	2000	886.5	889	890.5	895	896.5	870	873	225.95^{**}
	2010	897.1	910.5	914	925	950	963.5	970	87.18^{**}
	2016	1148.1	1185	1199	1253	1385	1470	1539	22.62^{**}
Compare Mean (Temporal)		13.79^{**}	12.53^{**}	12.2^{**}	10.75^{**}	8.33^{**}	7.18^{**}	6.62^{**}	-
TDS	1995	534.4	535.5	538.6	539.2	539.2	541.8	547.4	232.29^{**}
	2000	558.4	560.1	561.1	563.8	564.7	548.1	549.9	225.95^{**}
	2010	565.1	573.6	575.8	582.7	598.5	607.5	611.1	87.18^{**}
	2016	723.2	746.5	755.3	789.3	872.5	926.1	969.5	22.62^{**}
Compare Mean (Temporal)		13.79^{**}	12.53^{**}	12.2^{**}	10.75^{**}	8.33^{**}	7.18^{**}	6.62^{**}	-

Phosphate	1374	0.24	0.25	0.25	0.27	0.3	0.35	0.39	13.5**
	1379	0.31	0.35	0.37	0.4	0.48	0.54	0.59	11**
	1389	0.49	0.5	0.52	0.62	0.69	0.75	0.81	12.89**
	1395	0.77	0.85	0.98	1.25	1.86	2.34	3.15	4.74**
Compare Mean (Temporal)		3.82*	3.71*	3.31*	2.92*	2.36	2.18	1.91	-
Nitrate	1374	4.55	4.6	4.7	4.85	4.9	4.95	5.2	56.64**
	1379	4.66	4.71	4.83	4.95	5.2	5.3	5.5	41.73**
	1389	5.49	5.5	5.6	5.6	5.8	5.9	6.5	42.89**
	1395	7.28	7.45	7.89	8.5	8.85	9.1	9.5	26.08**
Compare Mean (Temporal)		8.71**	8.43**	7.78**	6.96**	6.82**	6.64**	6.79**	-
Sulfate	1374	0.31	0.33	0.35	0.36	0.38	0.4	0.45	20.88**
	1379	0.41	0.43	0.45	0.5	0.56	0.58	0.69	13.73**
	1389	1.59	2.3	2.5	2.68	3.2	3.5	3.8	9.72**
	1395	5.57	5.8	6.1	6.4	6.8	7.1	7.8	22.04**
Compare Mean (Temporal)		1.59	1.73	1.74	1.76	1.82	1.84	1.85	-

4. Conclusion

In this study, the effect of land use changes on water quality parameters in the Aras River was investigated for four time periods (1995, 2000, 2010 and 2016). The results showed a decrease in rangeland and an increase in agricultural and urban lands. Water quality decreased significantly decreased over the years with more intense changes in recent years. In general, we can conclude that the trend of land use change significantly affected the water quality of the Aras River, mainly due to the direct discharge of domestic, industrial and agricultural wastewater. Serious measures are necessary to prevent pollution in the Aras River, which serves the needs of thousands of people for drinking, agriculture, and industry.

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