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Dataset on the Assessments the Rate of Changing of Dissolved Oxygen and Temperature of Surface Water, Case Study: California, USA

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Abstract

Temperature affects aquatic organisms in many ways. Body temperature most aquatic organisms are the same as the surrounding water and fluctuate. Most aquatic organisms are limited to living in a temperature range, and when they are very low or high, they die. Temperature affects metabolism, reproduction and emergence. Temperature also affects the amount of photosynthesis of aquatic plants, the base of the aquatic food web. Pollutants can be toxic at higher temperatures. Most aquatic organisms need oxygen to survive. Oxygen is not part of the molecule of water, it is oxygen gas. Oxygen enters the water through the rain. Turbulence and wind through photosynthesis of aquatic plants. The body absorbs oxygen through structures such as cartilage or skin. Water-soluble ecosystems are stable drives. In the present study, temperature changes trending and dissolved oxygen concentration have been investigated. After that, the speed of temperature changes in degree and dissolved oxygen concentration in mg/L were calculated in each year. To achieve these terms, as can be seen in equation 1, the average of temperature and dissolved oxygen in one year compared with the same items in other years. An 11-year period of time (2007-2017) was considered. The result showed that the average value of DO changing rate in the area of study is equal to -0.138 $\mathrm{mg/L.y}$ and for T the average rate of change is equal to +0.02 ºC/y.

Keywords: Ecosystem, Dissolved oxygen, Temperature, Surface water, Photosynthesis

1 Introduction

Over the last decades, the trend of earth warming has been increased dramatically which has undesirable effects on different aspects of both human life and other living species in the world. One of the most significant factors that can be a threat by this issue is disturbing the mean dissolved oxygen concentration at a location in which a total of three-fourths of the earth’s oxygen supply is produced by phytoplankton in the oceans, and also the temperature impacts might appear as well. There would be not sufficient oxygen in the water on provided that water gets too warm [1], and the transport of dissolved oxygen from the surface ocean into the interior is a critical process sustaining aerobic life in the mesopelagic ecosystem [2].

According to a report by Wyrthi (1962), Three major processes have governed the oxygen in the world’s oceans: atmospheric exchange, ocean circulation and balance of photosynthesis which any alter in the balance of these parameters will affect the mean dissolved oxygen [3]. The increasing the surface heating leads to lessen dissolve oxygen into surface water and decline the reaching oxygen to the deep waters in deep oceans [4, 5 and 6].

Kaushal et al. (2010), observed the historical records for 20 of the 40 streams and rivers analyzed throughout US and reported that important effects such as eutrophication, ecosystem process, contaminant toxicity, and loss of aquatic biodiversity, could have been presented as long as stream temperature continue to increase at current rate (0.077°C per a year) [7].

Catherine et al. (2015), performed a study around the globe that about lake summer surface water temperature rose rapidly (global mean=0.34°C decade-1) between 1985 and 2009. Results showed that surface water warming dependent on combinations of climate and local characteristics, rather than just lake location. The most rapidly warming lakes are

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widely geographically distributed, and their warming is associated with interactions among different climates factors from seasonally ice-covered to ice-free lakes [8]. A Recent study by Jordan et al. (2018) perform a response in riverine communities to climate variables, and the results demonstrated that the composition of functional feeding groups is affected by changing climate conditions, which case functional change at the ecosystem level [9]. Bogard et al. (2008), investigated the spatial and temporal variability of dissolved oxygen in the southern California Current System in a 22-year (1984-2006), and a large dissolved oxygen up to $2.1\frac{\mu mol}{kg.y}$ were observed [10]. Also, significantly oxygen decline over a 50-year (1960-71 and 1998-2011) from Newport hydrographic line off central Oregon, one of the few locations in the northeast Pacific, was reported by Pierce et al. (2012) and suggested that subarctic influence along $\sigma_\theta 26.6$ [11]. Grantham et al. (2004), found that in 2002, cross-self transects revealed the development of the abnormally strong flow of subarctic water into the California Current system [12].

Meinvielle and Johnson (2013), investigated decreasing dissolved oxygen concentration, increasing warmth and salinity, and decreasing potential vorticity, using historical data from the World Ocean Database from 1950 to 2012 in the California Current System [13]. Kwon et al. (2016), studied central mode waters in the North Pacific, defined as neutral densities of 25.6-26.6, and suggest that the area through which the oxygen-rich mixed layer is detrained into the thermocline varies on a decade basis, with a connection to the Pacific Decadal Oscillation (PDO) [2]. Ren et al. (2016), presented the hydrographic cruise observation of declining dissolved oxygen collected along CalCOFI line 66.7 off of Monterey Bay, in the central California Current region. Results reported a significant decline in dissolved oxygen occurring in the northern, central, and southern California Current region, and between 1998 and 2013, dissolved oxygen decreased at the mean rate of $1.92\frac{\mu mol}{kg.year}$ which means a 40% drop from initial concentration [14].

2 Data

This study investigated the changes in DO level and T value. Data obtained from 10 different water quality monitoring stations (Table 1) in California, USA. These data consist of 4018 sets of data that belong to 11 years: 1/1/2007 to 31/12/2017 (for each station) that include the daily mean values of DO concentration (mg/L) and T (ºC). for each station some of the data missed (around 3% of DO data and 2% of T data, see Table 1) these data reproduced by placement them with an average of existed data that day but in other years. After reproducing the missing data annual average of data calculated for each year and each station, and rate of DO and T change calculated by the following procedure (equation 1 to 5):

$$\Delta T_{s,j,i}\left(\frac{°C}{year}\right)=\frac{T_{s,j}(°C)-T_{s,i}(°C)}{j-i}, 2007\le i,j\le 2017, j>i \quad (1)$$

$$\Delta DO_s\left(\frac{\frac{mg}{L}}{year}\right)=\frac{1}{55}\times\sum_{i,j}\Delta DO_{s,j,i}\left(\frac{\frac{mg}{L}}{year}\right) \quad (2)$$

$$\Delta T_s\left(\frac{°C}{year}\right)=\frac{1}{55}\times\sum_{i,j}\Delta T_{s,j,i}\left(\frac{°C}{year}\right) \quad (3)$$

$$\Delta DO\left(\frac{\frac{mg}{L}}{year}\right)=\frac{1}{11}\times\sum_{s}\Delta DO_s\left(\frac{\frac{mg}{L}}{year}\right) \quad (4)$$

$$\Delta T\left(\frac{°C}{year}\right)=\frac{1}{11}\times\sum_{s}\Delta T_s\left(\frac{°C}{year}\right) \quad (5)$$

where $\Delta T_{s,j,i}, \Delta DO_{s,j,i}$ are the rate of temperature and DO changes (respectively) in station number “s” in year “j” towards year “i". for each station number of 55 values existed for $\Delta T_{s,j,i}$ and 55 values for $\Delta DO_{s,j,i}$ these values are shown in Table 4 and 5.

3 Result and discussion

In the present study, temperature changes trending and dissolved oxygen concentration have been investigated. After that, the speed of temperature changes in degree and dissolved oxygen concentration in mg/L were calculated in each year. To achieve these terms, as can be seen in equation 1, the average of temperature and dissolved oxygen in one year compared with the same items in other years. An 11-year period of time (2007-2017) was considered. Consequently, the number of differences between year i and j are equal to:

$$\binom{11}{2}=\frac{11!}{2!\times 9!}=55 \quad (6)$$

Therefore, in both cases, the temperature’s speed ($\frac{\Delta T}{year}$), and the speed of Dissolved oxygen concentration ($\frac{\Delta DO}{year}$), are increasing by the rate of ($\frac{°C}{year}$). Advantages of this method, which is using for the first time to calculating the mentioned parameters, is the temperature and dissolved oxygen of the whole period is comparing with all previous years not only with the year before, and consequences would be expressed on average. With regard to the average temperature in all stations (17.4°C) and table 3, there is a 0.2 mg/L difference between DO at 17.4 and 18 degrees. It takes 30 years to temperature from 17.4 to 18 provided that the increasing rate of temperature continues as the same range is now (0.02 degree per year). Also, dissolved oxygen should decrease 0.12 mg/L, but the results are shown that DO decreases speed is 0.138 mg/L per a year which means over the next 30 years the lessen dissolved oxygen is going to be 4 mg/L or so that is 30 times lower than what is expected due to the temperature rising. Hence, in addition to increasing temperature on a yearly basis, the rivers in this area of the America is getting polluted to BOD and COD. The increase in the sum of BOD and COD is indicating in equation 7 to 13 $in\ 30\ years$.

Table 1: Stations profile and number of missing data

Station	Code	Address	Latitude	Longitude	Elv	NMDO	NMT
S1	B9537800	Old River at Tracy Wildlife Association	37.80283	-121.457	0	31	27
S2	B9536500	Old River Barrier near DMC (Below) - WQ	37.81097	-121.544	0	64	56
S3	B9540000	Old River @ Head - WQ	37.80759	-121.331	0	253	235
S4	B9550600	Middle River near Tracy Blvd Bridge	37.88142	-121.467	6	150	93
S5	B9553100	Middle River near Howard Road Bridge	37.87618	-121.383	0	96	52
S6	B9550000	Middle River at Union Point - WQ	37.89077	-121.488	0	57	29
S7	B9554100	Middle River @ Undine Road - WQ	37.83394	-121.386	0	114	61
S8	B9530000	Grant Line Canal at Tracy Blvd Bridge - WQ	37.82011	-121.45	0	107	84
S9	B9529500	Grant Line Canal near Clifton Court Forebay - WQ	37.82012	-121.545	-21	60	25
S10	B9532500	Doughty Cut above Grant Line Canal - WQ	37.81472	-121.425	0	344	259

Table 2: Annual average DO (mg/L) values of stations

	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
2007	9.39	8.81	11.34	9.58	9.24	9.33	10.26	9.28	8.72	9.82
2008	9.66	8.37	11.33	9.11	8.20	9.01	10.34	9.03	8.65	9.70
2009	9.66	8.23	10.62	9.19	8.56	9.01	9.90	9.37	8.75	9.29
2010	8.63	7.72	9.90	8.41	7.95	8.56	9.55	8.97	8.06	9.19
2011	9.06	8.45	9.74	7.80	9.28	8.56	9.39	9.46	9.05	9.50
2012	8.13	7.46	10.50	7.63	6.81	8.60	9.88	8.49	8.09	9.44
2013	6.87	7.90	8.93	7.89	6.37	8.87	8.88	7.76	8.54	8.04
2014	7.38	7.90	9.01	7.46	4.86	8.25	8.69	7.96	8.12	7.72
2015	7.29	8.09	9.11	7.95	5.00	8.52	8.60	8.02	8.25	7.38
2016	7.87	8.35	9.41	8.08	4.96	8.49	9.11	8.13	8.65	7.42
2017	8.53	8.52	9.40	7.90	8.83	8.52	9.08	9.16	9.12	8.74

Table 3: Annual average T (ºC) values of stations.

1	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
2007	17.61	17.15	17.67	17.36	17.65	17.36	17.36	17.53	17.46	17.60
2008	17.70	17.15	17.67	17.25	17.44	17.32	17.40	17.24	17.38	17.34
2009	17.65	17.10	17.64	17.32	17.49	17.38	17.43	17.56	17.33	17.22
2010	17.39	17.09	16.96	17.27	17.42	17.20	17.10	17.14	17.08	16.83
2011	15.38	15.88	15.02	16.34	15.30	16.56	14.99	15.12	15.42	15.14
2012	17.85	17.31	17.61	17.42	17.58	17.55	17.50	17.74	17.68	17.75
2013	17.26	17.06	17.57	17.18	17.09	17.35	17.50	17.55	17.30	17.51
2014	18.57	18.61	18.90	18.55	18.30	18.66	18.62	18.88	18.69	18.85
2015	18.00	18.33	18.68	18.22	17.73	18.49	18.23	18.48	18.41	18.59
2016	18.49	18.00	18.41	18.12	18.02	18.23	18.40	18.41	18.21	18.49
2017	16.37	16.89	15.52	17.13	16.28	17.37	15.68	15.80	16.03	15.93

Table 4: Values of $\Delta DO_{s,j,i}$, the horisental year number are "i" values and the vertical year lable in the first column (on the left side of table) are "j" values, the value of ΔDO_s come in table, too.

S1	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
2008	0.2643									
2009	0.1336	0.0029					ΔDO_1=	-0.19	(mg/L.y)	
2010	-0.254	-0.513	-1.028							
2011	-0.083	-0.198	-0.299	0.4307						
2012	-0.253	-0.382	-0.511	-0.252	-0.934					
2013	-0.421	-0.558	-0.698	-0.587	-1.096	-1.259				
2014	-0.288	-0.379	-0.456	-0.313	-0.561	-0.374	0.5108			
2015	-0.264	-0.339	-0.396	-0.269	-0.445	-0.281	0.2074	-0.096		
2016	-0.169	-0.223	-0.256	-0.127	-0.238	-0.064	0.334	0.2455	0.587	
2017	-0.086	-0.125	-0.141	-0.014	-0.088	0.0808	0.4157	0.384	0.6239	0.6608
S2	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
2008	-0.44									
2009	-0.291	-0.141					ΔDO_2=	-0.021	(mg/L.y)	
2010	-0.363	-0.325	-0.509							
2011	-0.091	0.0249	0.1078	0.7242						
2012	-0.27	-0.228	-0.257	-0.131	-0.985					
2013	-0.152	-0.095	-0.083	0.0587	-0.274	0.4373				
2014	-0.13	-0.078	-0.066	0.045	-0.181	0.2206	0.004			
2015	-0.091	-0.041	-0.024	0.0729	-0.09	0.2086	0.0942	0.1844		
2016	-0.052	-0.003	0.0163	0.1037	-0.02	0.2209	0.1488	0.2212	0.258	
2017	-0.029	0.0166	0.0363	0.1141	0.0124	0.212	0.1557	0.2063	0.2172	0.1765
S3	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
2008	-0.009									
2009	-0.36	-0.711					ΔDO_3=	-0.218	(mg/L.y)	
2010	-0.48	-0.715	-0.719							
2011	-0.4	-0.53	-0.439	-0.16						
2012	-0.167	-0.207	-0.038	0.3019	0.7635					
2013	-0.401	-0.48	-0.422	-0.323	-0.405	-1.574				
2014	-0.333	-0.387	-0.322	-0.223	-0.244	-0.748	0.0784			
2015	-0.278	-0.317	-0.251	-0.158	-0.157	-0.464	0.0909	0.1034		
2016	-0.214	-0.24	-0.172	-0.081	-0.066	-0.273	0.1608	0.202	0.3006	
2017	-0.194	-0.214	-0.152	-0.071	-0.057	-0.221	0.1176	0.1306	0.1442	-0.012
S4	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
2008	-0.464									
2009	-0.196	0.0714					ΔDO_4=	-0.164	(mg/L.y)	
2010	-0.389	-0.351	-0.774							
2011	-0.444	-0.437	-0.691	-0.609						
2012	-0.389	-0.37	-0.517	-0.389	-0.169					
2013	-0.281	-0.245	-0.324	-0.174	0.0439	0.2571				
2014	-0.303	-0.277	-0.346	-0.239	-0.116	-0.089	-0.436			

2015	-0.204	-0.167	-0.206	-0.093	0.0361	0.1046	0.0283	0.4922		
2016	-0.166	-0.129	-0.158	-0.055	0.0561	0.1124	0.0641	0.314	0.1359	
2017	-0.168	-0.135	-0.161	-0.074	0.0156	0.0526	0.0014	0.1471	-0.025	-0.187
S5	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
2008	-1.041									
2009	-0.344	0.3521					ΔDO_5=	-0.271	(mg/L.y)	
2010	-0.431	-0.126	-0.603							
2011	0.0102	0.3605	0.3647	1.3326						
2012	-0.487	-0.348	-0.581	-0.571	-2.474					
2013	-0.479	-0.367	-0.547	-0.528	-1.459	-0.444				
2014	-0.626	-0.557	-0.739	-0.773	-1.475	-0.976	-1.507			
2015	-0.53	-0.457	-0.592	-0.59	-1.07	-0.602	-0.682	0.144		
2016	-0.476	-0.406	-0.514	-0.499	-0.865	-0.463	-0.47	0.0487	-0.047	
2017	-0.041	0.0696	0.0343	0.1254	-0.076	0.4038	0.6156	1.3233	1.913	3.8726
S6	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
2008	-0.318									
2009	-0.159	0					ΔDO_6=	-0.073	(mg/L.y)	
2010	-0.256	-0.225	-0.449							
2011	-0.191	-0.149	-0.223	0.0025						
2012	-0.145	-0.101	-0.135	0.0223	0.0422					
2013	-0.075	-0.027	-0.033	0.1053	0.1566	0.2711				
2014	-0.153	-0.125	-0.15	-0.076	-0.102	-0.174	-0.619			
2015	-0.101	-0.07	-0.081	-0.008	-0.011	-0.028	-0.178	0.2631		
2016	-0.093	-0.065	-0.074	-0.011	-0.014	-0.028	-0.128	0.1173	-0.028	
2017	-0.08	-0.054	-0.061	-0.005	-0.006	-0.016	-0.088	0.089	0.0019	0.0323
S7	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
2008	0.0791									
2009	-0.18	-0.439					ΔDO_7=	-0.148	(mg/L.y)	
2010	-0.238	-0.397	-0.355							
2011	-0.218	-0.316	-0.255	-0.155						
2012	-0.077	-0.116	-0.008	0.1646	0.4842					
2013	-0.231	-0.293	-0.257	-0.224	-0.258	-1.001				
2014	-0.225	-0.275	-0.243	-0.215	-0.234	-0.594	-0.187			
2015	-0.208	-0.249	-0.218	-0.19	-0.199	-0.427	-0.14	-0.093		
2016	-0.128	-0.154	-0.114	-0.073	-0.057	-0.192	0.0771	0.2089	0.5113	
2017	-0.119	-0.141	-0.103	-0.067	-0.053	-0.16	0.0502	0.1292	0.2405	-0.03
S8	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
2008	-0.248									
2009	0.0438	0.336					ΔDO_8=	-0.092	(mg/L.y)	
2010	-0.104	-0.032	-0.399							
2011	0.0455	0.1434	0.0471	0.4935						
2012	-0.158	-0.135	-0.292	-0.239	-0.971					

2013	-0.254	-0.255	-0.403	-0.404	-0.852	-0.734				
2014	-0.189	-0.18	-0.283	-0.254	-0.503	-0.269	0.1962			
2015	-0.158	-0.145	-0.225	-0.191	-0.362	-0.159	0.1286	0.0611		
2016	-0.128	-0.113	-0.178	-0.141	-0.268	-0.092	0.1222	0.0853	0.1095	
2017	-0.013	0.0137	-0.027	0.0267	-0.051	0.1328	0.3494	0.4004	0.5701	1.0308
S9	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
2008	-0.065									
2009	0.0141	0.0933					ΔDO_9=	0.0074	(mg/L.y)	
2010	-0.22	-0.297	-0.687							
2011	0.0832	0.1327	0.1523	0.9918						
2012	-0.126	-0.141	-0.219	0.0147	-0.962					
2013	-0.029	-0.022	-0.051	0.1616	-0.254	0.4553				
2014	-0.086	-0.09	-0.126	0.014	-0.312	0.0134	-0.429			
2015	-0.059	-0.058	-0.084	0.0371	-0.202	0.052	-0.15	0.1292		
2016	-0.008	0	-0.014	0.0982	-0.081	0.1399	0.0348	0.2665	0.4038	
2017	0.04	0.0517	0.0465	0.1512	0.0112	0.2059	0.1435	0.3342	0.4367	0.4696
S10	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
2008	-0.12									
2009	-0.266	-0.413					ΔDO_{10}=	-0.206	(mg/L.y)	
2010	-0.212	-0.258	-0.104							
2011	-0.082	-0.069	0.1025	0.3094						
2012	-0.076	-0.065	0.0503	0.1276	-0.054					
2013	-0.297	-0.333	-0.313	-0.382	-0.728	-1.401				
2014	-0.301	-0.331	-0.315	-0.367	-0.593	-0.862	-0.323			
2015	-0.306	-0.332	-0.319	-0.362	-0.53	-0.688	-0.331	-0.34		
2016	-0.267	-0.286	-0.268	-0.295	-0.416	-0.506	-0.208	-0.15	0.0399	
2017	-0.108	-0.107	-0.068	-0.063	-0.125	-0.14	0.1757	0.3418	0.6829	1.3259

Table 5: Values of $\Delta T_{s,j,i}(\frac{°C}{year})$, the horizontal year number are "i" values and the vertical year label in the first column (on the left side of table) are "j" values, the value of ΔT_s come in table, too.

S1	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
2008	0.0852									
2009	0.021	-0.043					ΔT_1=	-0.003	(ºC/y)	
2010	-0.074	-0.154	-0.264							
2011	-0.558	-0.772	-1.137	-2.01						
2012	0.0483	0.0391	0.0666	0.2318	2.4734					
2013	-0.058	-0.086	-0.097	-0.041	0.9427	-0.588				
2014	0.1371	0.1458	0.1836	0.2954	1.0638	0.359	1.306			
2015	0.0492	0.0441	0.0586	0.1231	0.6563	0.0506	0.3699	-0.566		
2016	0.0973	0.0988	0.1191	0.1829	0.6214	0.1584	0.4072	-0.042	0.4818	
2017	-0.124	-0.147	-0.16	-0.145	0.1654	-0.296	-0.223	-0.733	-0.816	-2.11
S2	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016

2008	-0.001									
2009	-0.026	-0.051					ΔT_2=	0.0709	(ºC/y)	
2010	-0.019	-0.028	-0.006							
2011	-0.317	-0.423	-0.608	-1.211						
2012	0.0331	0.0417	0.0726	0.1118	1.4344					
2013	-0.014	-0.017	-0.009	-0.01	0.591	-0.252				
2014	0.2082	0.2431	0.3019	0.3789	0.9088	0.646	1.5444			
2015	0.1482	0.1695	0.2062	0.2487	0.6135	0.3399	0.6361	-0.272		
2016	0.0941	0.106	0.1284	0.1508	0.4231	0.1703	0.3112	-0.305	-0.339	
2017	-0.025	-0.028	-0.025	-0.028	0.1691	-0.084	-0.042	-0.571	-0.72	-1.10
S3	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
2008	0.0019									
2009	-0.015	-0.032					ΔT_3=	-0.023	(ºC/y)	
2010	-0.235	-0.353	-0.674							
2011	-0.663	-0.884	-1.31	-1.945						
2012	-0.012	-0.015	-0.009	0.3231	2.5916					
2013	-0.017	-0.02	-0.017	0.2015	1.275	-0.042				
2014	0.1758	0.2048	0.2522	0.4838	1.2936	0.6446	1.3308			
2015	0.1262	0.1439	0.1733	0.3428	0.9149	0.356	0.5548	-0.221		
2016	0.0822	0.0923	0.1101	0.2408	0.6781	0.1997	0.2801	-0.245	-0.269	
2017	-0.215	-0.239	-0.264	-0.206	0.084	-0.417	-0.511	-1.126	-1.578	-2.88
S4	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
2008	-0.11									
2009	-0.02	0.0701					ΔT_4=	0.0599	(ºC/y)	
2010	-0.029	0.0114	-0.047							
2011	-0.254	-0.302	-0.488	-0.928						
2012	0.0113	0.0416	0.0321	0.0718	1.0715					
2013	-0.03	-0.014	-0.035	-0.031	0.4174	-0.237				
2014	0.17	0.2166	0.2459	0.3192	0.7349	0.5666	1.3699			
2015	0.1081	0.1392	0.1507	0.1903	0.4699	0.2694	0.5224	-0.325		
2016	0.0849	0.1092	0.1148	0.1418	0.3558	0.1769	0.3147	-0.213	-0.101	
2017	-0.023	-0.014	-0.024	-0.021	0.1303	-0.058	-0.013	-0.474	-0.549	-0.99
S5	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
2008	-0.218									
2009	-0.082	0.0542					ΔT_5=	-0.024	(ºC/y)	
2010	-0.077	-0.006	-0.067							
2011	-0.588	-0.712	-1.095	-2.123						
2012	-0.015	0.0361	0.03	0.0783	2.2793					
2013	-0.094	-0.069	-0.1	-0.112	0.8938	-0.492				
2014	0.0919	0.1435	0.1613	0.2183	0.9986	0.3583	1.2082			
2015	0.0093	0.0418	0.0397	0.0609	0.6068	0.0494	0.3199	-0.568		
2016	0.0409	0.0733	0.076	0.0997	0.5442	0.1104	0.3111	-0.137	0.2937	

2017	-0.137	-0.128	-0.151	-0.163	0.1635	-0.26	-0.202	-0.672	-0.723	-1.74
S6	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
2008	-0.042									
2009	0.01	0.0623					ΔT_6=	0.0807	(ºC/y)	
2010	-0.055	-0.062	-0.186							
2011	-0.201	-0.254	-0.412	-0.638						
2012	0.0379	0.058	0.0566	0.1781	0.9941					
2013	-0.002	0.006	-0.008	0.0514	0.3961	-0.202				
2014	0.185	0.2229	0.255	0.3654	0.6999	0.5527	1.3074			
2015	0.1412	0.1675	0.185	0.2593	0.4836	0.3134	0.571	-0.165		
2016	0.0959	0.1132	0.1205	0.1716	0.3336	0.1684	0.2919	-0.216	-0.266	
2017	0.0011	0.0059	-0.001	0.0253	0.1359	-0.036	0.0058	-0.428	-0.559	-0.85
S7	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
2008	0.0449									
2009	0.0375	0.0301					ΔT_1=	-8E-04	(ºC/y)	
2010	-0.085	-0.151	-0.331							
2011	-0.591	-0.803	-1.219	-2.107						
2012	0.0284	0.0242	0.0222	0.199	2.5048					
2013	0.0236	0.0193	0.0166	0.1326	1.2523	-1E-04				
2014	0.1803	0.2028	0.2374	0.3795	1.2083	0.5601	1.1203			
2015	0.1091	0.1183	0.133	0.2258	0.809	0.2437	0.3657	-0.389		
2016	0.1163	0.1252	0.1387	0.2171	0.6819	0.2261	0.3016	-0.108	0.1733	
2017	-0.168	-0.192	-0.219	-0.203	0.1139	-0.364	-0.455	-0.981	-1.276	-2.72
S8	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
2008	-0.288									
2009	0.0166	0.3215					ΔT_8=	0.0076	(ºC/y)	
2010	-0.13	-0.05	-0.422							
2011	-0.603	-0.708	-1.223	-2.023						
2012	0.0413	0.1236	0.0577	0.2977	2.6189					
2013	0.0038	0.0622	-0.003	0.1373	1.2177	-0.184				
2014	0.193	0.2732	0.2635	0.435	1.2545	0.5723	1.3282			
2015	0.1193	0.1776	0.1536	0.2688	0.8418	0.2495	0.466	-0.396		
2016	0.0976	0.1458	0.1207	0.2113	0.6582	0.168	0.2852	-0.236	-0.076	
2017	-0.172	-0.16	-0.22	-0.191	0.1147	-0.386	-0.437	-1.025	-1.339	-2.60
S9	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
2008	-0.076									
2009	-0.063	-0.051					ΔT_9=	0.0102	(ºC/y)	
2010	-0.126	-0.151	-0.251							
2011	-0.51	-0.655	-0.957	-1.663						
2012	0.0442	0.0742	0.1158	0.2993	2.2615					
2013	-0.027	-0.017	-0.008	0.0724	0.9401	-0.381				
2014	0.1765	0.2185	0.2723	0.4032	1.0919	0.5071	1.3956			

2015	0.119	0.1468	0.1797	0.2659	0.748	0.2436	0.556	-0.284		
2016	0.0838	0.1038	0.1258	0.1887	0.559	0.1334	0.3049	-0.24	-0.197	
2017	-0.143	-0.15	-0.163	-0.15	0.1019	-0.33	-0.317	-0.888	-1.19	-2.18
S10	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
2008	-0.253									
2009	-0.187	-0.121					ΔT_{10}=	0.0233	(ºC/y)	
2010	-0.256	-0.257	-0.393							
2011	-0.615	-0.735	-1.042	-1.691						
2012	0.0316	0.1028	0.1774	0.4627	2.6162					
2013	-0.014	0.0334	0.072	0.2271	1.186	-0.244				
2014	0.1785	0.2505	0.3248	0.5043	1.2359	0.5458	1.3358			
2015	0.124	0.1778	0.2276	0.3518	0.8625	0.2779	0.5389	-0.258		
2016	0.099	0.1431	0.1808	0.2765	0.6699	0.1833	0.3258	-0.179	-0.1	
2017	-0.167	-0.157	-0.161	-0.128	0.1321	-0.365	-0.395	-0.972	-1.329	-2.55

The average value of DO changing rate in the area of study is equal to -0.138 mg/L.y and for T the average rate of changing is equal to +0.02 ºC/y.

$$\bar{T}_{2007-2017} = 17.4°C \quad (7)$$

$$\frac{2007+2017}{2} + 30 = 2042 \quad (8)$$

$$T_{2042} = \bar{T}_{2007-2017} + 30 \times \Delta T = 17.4 + 30 \times 0.02 \frac{°C}{year} = 18°C \quad (9)$$

$$\Delta DO_{2012-2042} should = 9.68 - 9.8 = -0.12 \frac{mg}{L} \quad (10)$$

Or

$$-\frac{0.12}{3} = -0.004 \frac{mg}{year} \quad (11)$$

but

$$\Delta DO = -0.138 \frac{mg}{year} \quad (12)$$

$$-0.138 - (-0.004) = -0.134 \frac{mg}{L} \quad (13)$$

Such results are similar to those of other researchers as presented in the table below (Information adapted from: Water, Water everywhere: Water Quality Factors Reference Unit, HACH Inc). The amount of soluble oxygen that distilled water can hold at a certain temperature. The above equations show that in the average annual temperature conditions, 0.004 mg/l of dissolved oxygen is decreased due to heating and temperature increase, and in 0.134 mg/l year, BOD and COD contamination are added.

4 Conclusion

Temperature affects aquatic organisms in many ways. Body temperature most aquatic organisms are the same as the surrounding water and fluctuate. Most aquatic organisms are limited to living in a temperature range, and when they are very low or high, they die. Temperature affects metabolism, reproduction and emergence.

Table 6: The amount of soluble oxygen that distilled water can hold at a certain temperature

Temp (^{0}C)	Solubility (mg/l)
0	14.6
1	14.2
2	13.8
3	13.5
4	13.1
5	12.8
6	12.5
7	12.2
8	11.9
9	11.6
10	11.3
11	11.1
12	10.9
13	10.6
14	10.4
15	10.2
16	10.0
17	9.8
18	9.6
19	9.4
20	9.2
21	9.0
22	8.9
23	8.7
24	8.6
25	8.4
26	8.2
27	8.1
28	7.9
29	7.8
30	7.7

Adapted from: Water, Water Everywhere: Water Quality Factors Reference Unit, HACH Inc

Temperature also affects the amount of photosynthesis of aquatic plants, the base of the aquatic food web. Pollutants can be toxic at higher temperatures. Most aquatic organisms need oxygen to survive. Oxygen is not part of the molecule of water, it is oxygen gas. Oxygen enters the water through the rain. Turbulence and wind through photosynthesis of aquatic plants. The body absorbs oxygen through structures such as cartilage or skin. In the present study, temperature changes trending and dissolved oxygen concentration have been investigated. After that, the speed of temperature changes in degree and dissolved oxygen concentration in mg/L were calculated in each year. To achieve these terms, as can be seen in equation 1, the average of temperature and dissolved oxygen in one year compared with the same items in other years. An 11-year period of time (2007-2017) was considered. The result showed that the average value of DO changing rate in the area of study is equal to -0.138 mg/L.y and for T the average rate of change is equal to +0.02 ºC/y.
In this study, the method of comparing temperature and dissolved oxygen during a specified period is a variant in this study. The results also show how the process of change has been and how quickly the temperature decreases with increasing dissolved oxygen. The results also show that BOD and COD inputs are increasing rapidly. This is a matter of concern and in addition affects global warming and pollution sources such as industries and the quality of water resources and ecosystems, so the reasons for this along the river should be studied in depth.

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