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HEAVY METAL POLLUTION INDEX (HPI) IN SURFACE WATER BETWEEN ALAKIR DAM AND ALAKIR BRIDGE, ANTALYA-TURKEY

ALAKIR BARAJI VE ALAKIR KÖPRÜSÜ ARASINDAKİ YÜZEY SUYUNUN AĞIR METAL KİRLİLİK İNDEKSİ (HPI), ANTALYA-TÜRKİYE

Yasemin LEVENTELI[1*], *Fusun YALCIN*[2]

[1]Akdeniz Üniversitesi, Jeoloji Mühendisliği Bölümü, Antalya, Türkiye
[2]Akdeniz Üniversitesi, Matematik Bölümü, Antalya, Türkiye

*Sorumlu Yazar / Corresponding Author: Yasemin LEVENTELI, leventeli@akdeniz.edu.tr

ÖZET

Nüfus artışına bağlı olarak temiz suya erişimin önemi artmıştır. Söz konusu gereksinim içme ve sulama suyu ile sınırlı değildir; enerji üretimi ve endüstri gelişiminde de önemlidir. Antalya gerek göç alması, gerek tarım ve endüstrideki büyümesi ile en çok su ihtiyacının arttığı iller arasındadır. Kumluca artan nüfusu, önemli tarım alanları ve hemen kuzeyindeki hidroelektrik santralleri ile Antalya'nın önemli ilçelerindendir. Her mevsim tarım yapılmaktadır. Bu çalışmada, artan nüfusun ve tarımın etkilerini anlayabilmek için, ovayı baştanbaşa kesen yüzey sularında ağır metal anomalileri araştırılmıştır. Bunun için Mayıs 2018 tarihinde, sistematik olarak, Alakır Barajı ve Alakır Köprüsü arasındaki 48 lokasyondan numune alınmıştır. Kimyasal analiz sonuçlarında elde edilen veriler HPI istatistiksel analiz yardımıyla yorumlanmıştır. HPI değerindeki anomaliler iki bölgede yoğunlaşmıştır. Bu gruplaşmada üst bölgede barajın, alt bölgede tarımsal faaliyetlerin etkili olduğu düşünülmektedir.

Anahtar Kelimeler: Yüzey Suyu, Ağır Metal, Kirlilik İndeksi, HPI, İstatistik, Alakır.

ABSTRACT

The importance of getting the clean water has increased due to population growth. This requirement is not limited to drinking and irrigation water; it is also important in energy production and industry development. Antalya is one of the provinces with the highest water demand due to its migration, agriculture and industry growth. Kumluca is one of the important districts of Antalya with its growing population, important agricultural areas and hydroelectric power plants just north of it. Agricultural is performed in all season. Inthis study, in order to understand the effects of increasing population and agriculture, heavy metal anomalies were investigated in surface waters that passes throughout the plain. In May 2018, a systematic sampling was taken from 48 locations between Alakir Dam and Alakir Bridge. The data obtained in the results of chemical analysis was interpreted using HPI statistical analysis. HPI value anomalies were concentrated in two regions. These grouping were considered that because of the dam in the upper region; because of the agricultural activities in the lower region.

Keywords: Surface Water, Heavy Metal, Pollution Index, HPI, Statistics, Alakir.

INTRODUCTION

The importance of water in human health is well known. Therefore, the water pollution, whatever the source, affects adversely human health. On the other hand, it is necessary to know the reason to produce proper and effective solutions. The urbanization, industrial zones, agricultural areas and similar reasons may cause the pollution and they called "anthropogenic" (Fernandez-Luqueno et al., 2013); besides that, sometimes geological factors may cause water pollution. A lot of statistical methods have been developed to measure and evaluate the water pollution (Prasad and Bose 2001; Yalcin et al., 2007; Yalcin et al., 2008; Prasanna et al. 2012; Dadolahi-Sohrab et al. 2012; Yalcin et al., 2017; Cengiz et al., 2017; Bytyçi et al. 2018; Dutta et al., 2018; El-Tohamy et al. 2018; Qu et al. 2018; Leventeli et al. 2019; Singh et al. 2018; Wen et al., 2019; Singh et al. 2019). One of them is heavy metal pollution index (HPI). There are a lot of hydroelectricity power plant (HPP) with small dam, around the country. One of them is Alakir Dam. It is located on the western part of Antalya. The stream flows among greenhouses and settlement areas in the plain; and there is a bridge where it reaches the Mediterranean, Alakir Bridge. The surface water samples have been taken from the locations between Alakir Dam and Alakir Bridge.

MATERIALS AND METHODS

The study area is located on the western part of Antalya Gulf, between Alakir Dam and Alakir Bridge (**Figure 1**). Agricultural and residential areas are common in the region. The samples were collected from 48 locations in May 2018 based on land use properties of the study area. The water samples have been taken by 1 L polythene containers. The samples have been prepared according to EPA 3005A (1992) method (Rohrbough, 1986; ASTM 1985). The Inductively Coupled Plasma – Mass Spectrometer (ICP-MS) device has been used for the experimental studies in the Research Center Laboratory of Akdeniz University. While 43 samples could be analyzed; the rest 5 samples (K1, K2, K4, K12, K19) could not be studied. The heavy metal values (ppb) are given in **Table 1.**

Figure 1. The Location Map of the Study Area.

HEAVY METAL POLLUTION INDEX (HPI)

The geological and anthropogenic factors may cause the accumulation of heavy metals in groundwater. Some trace metals such as cobalt (Cd), copper (Cu), zinc (Zn) and selenium (Se) are essential for humans, but its high level may cause physiological disorders (Kumar et. al., 2019). The heavy metal pollution index (HPI) shows the water quality and is calculated from the concentration of heavy metal in water. Various algorithms have been proposed and used by different researchers to calculate HPI and to determine water quality (Chaturvedi et al., 2018; Horton, 1965; Brown et al., 1970; Dunnette, 1979; CCME, 2001; Mohan et al., 1996; Edet and Offiong, 2002; Prasanna et al., 2012; Tiwari et al., 2015; Islam et al., 2015). The heavy metal pollution index (HPI) is a very useful tool in estimating the overall effects; because, it contains the concentration of all the measured metals. The Heavy Metal Pollution Index (HPI) and the sub-index of each parameter (*Qi*) are calculated using the following correlations (Leventeli et al., 2019).

$$Q_i = \sum_{i=1}^{n} \frac{(M_i - I_i)}{(S_i - I_i)} \text{x}100 \quad (1)$$

Wi is the unit weight of the *i-th* parameter, and *Qi* is the sub-index of the i-th parameter. *n* is the number of parameters considered. *Mi* is the measured value of the parameter *i*. *Ii* and *Si* give the ideal and standard values of the *i-th* parameter.

$$HPI = \frac{\sum_{i=1}^{n} W_i Q_i}{\sum_{i=1}^{n} W_i} \quad (2)$$

The analysis results were interpreted based on Nasrabadi (2015).

Table 1. The heavy Metal Values (ppb)

	As	Mn	Ni	Cu	Pb	Fe	Sr	Cr		As	Mn	Ni	Cu	Pb	Fe	Sr	Cr
K3	0,509	14,731	15,054	3,142	0,35	65,734	134,294	1,094	**K29**	0,715	5,73	3,808	0,117	0,191	62,181	223,526	0,334
K5	0,748	10,047	45,716	2,126	0,222	95,871	151,882	1,041	**K30**	0,721	8,214	4,461	0,755	0	76,452	235,509	0,656
K6	0,64	16,885	23,002	5,583	2,914	122,005	149,746	1,366	**K31**	0,764	7,436	7,275	1,787	0	67,098	213,031	0,501
K7	0,654	11,014	32,955	1,914	0	102,467	149,637	0,659	**K32**	0,812	10,534	11,99	6,024	0,466	66,793	200,516	0,851
K8	0,5	11,407	24,433	6,243	0,804	75,561	137,657	1,201	**K33**	0,947	11,249	10,46	3,346	0,208	116,605	237,565	0,575
K9	0,504	10,642	7,482	2,483	0,502	73,493	152,505	1,128	**K34**	0,817	3,118	1,378	0	0	66,605	216,04	0,178
K10	0,513	12,419	12,66	4,469	1,236	84,424	141,689	1,787	**K35**	0,89	9,107	4,907	2,313	1,55	81,968	198,375	0,927
K11	0,539	11,32	11,706	4,634	0,792	88,246	152,474	1,142	**K36**	0,809	7,494	2,578	1,07	0	51,126	168,38	0,131
K13	0,463	4,174	2,082	0	0	68,836	156,381	0,523	**K37**	0,807	8,631	3,432	1,82	0,294	55,298	165,202	0,173
K14	0,493	4,9	1,955	0	0	70,15	152,387	0,633	**K38**	0,77	11,077	4,12	1,817	0	72,565	191,921	0
K15	0,39	6,468	6,658	0,519	0	55,95	144,122	0,285	**K39**	0,645	12,086	5,45	2,434	0	90,173	217,203	0
K16	0,441	3,734	1,773	0	0	60,627	151,296	0,807	**K40**	0,652	15,34	5,256	1,01	0	99,547	253,461	0
K17	0,404	3,636	1,852	0	0	60,171	146,997	0,51	**K41**	0,906	13,403	3,091	0	0	114,033	196,179	0
K18	0,394	3,029	1,571	0	0	56,549	148,155	0,656	**K42**	0,934	17,646	11,171	1,373	0,144	79,979	209,738	0
K20	0,447	5,713	4,705	2,601	0	44,73	145,194	0,234	**K43**	0,924	22,443	4,537	0,6341	0	89,862	224,802	0
K21	0,49	2,824	1,512	0	0	55,379	152,845	0,625	**K44**	1,021	32,975	6,173	1,33	0	106,572	230,234	0,117
K22	0,5	6,276	3,541	0,616	0	60,472	148,079	0,18	**K45**	1,08	42,536	7,399	1,259	0	122,076	232,321	0,217
K23	0,831	6,412	2,541	1,636	0	91,98	195,955	0,458	**K46**	1,136	68,529	4,922	0,535	0	180,711	254,66	0,516
K24	0,684	1,655	0,417	0	0	53,064	215,854	0,772	**K47**	1,202	44,517	11,738	1,691	0	151,272	251,1	0,472
K25	0,71	0,707	0,59	0	0	75,664	264,569	0,719	**K48**	1,117	40,747	34,55	3,812	0,103	155,83	254,868	0,189
K26	3,074	26,46	5,878	0,981	0,585	47,975	86,477	0									
K27	2,473	42,669	9,207	0,683	2,432	134,979	205,535	0									
K28	0,711	8,51	11,457	0,66	1,221	79,078	238,523	0,553									

RESULTS

The results of the HPI anaysis, applied to the results of chemical studies of the samples collected from the study area, show differences among themselves (**Figure 2**). These differences between locations have been changed according to heavy metal content. The highest value has been determined as 85,833 and the lowest value has been identified as 20,7686. As seen from the **Figure 3**, the locations which show anomalies have been concentrated in two areas. The first one is K5 with highest HPI value in the upper area, first sampling locations. The other one is K8 in lower area. The locations between K1 – K11 are located in first or upper area. This region is effective from the downstream of the dam until the K11 location. The source of anomalies of this region can be defined as dam impact. The locations between K13 – K48 are located in second or lower area. External factors affect this region can be considered as different from the dam's factors.

In this case, new research studies can be done about the source of anomalies. The heavy metal consantration of the first area could not be moved to the second area. It is possible to say that the heavy metals are deposeted; could not move along the stream and could not reach the last locations.

All HPI values of the investigated area were below the HPI values in the study by Nasrabadi (2015). According to this study, there is no risk about heavy metal pollution. According to a similar study on the quality of water (Sirajudeen et al., 2014) K6, K7, K8, K28, K32, K33, K46, K47 have "Poor" quality; K5 and K8 have "Very Poor" quality (**Table 2**). The study area has a single location with "very good" quality, which is named as K26. Other locations can be considered as "good" and without any problems.

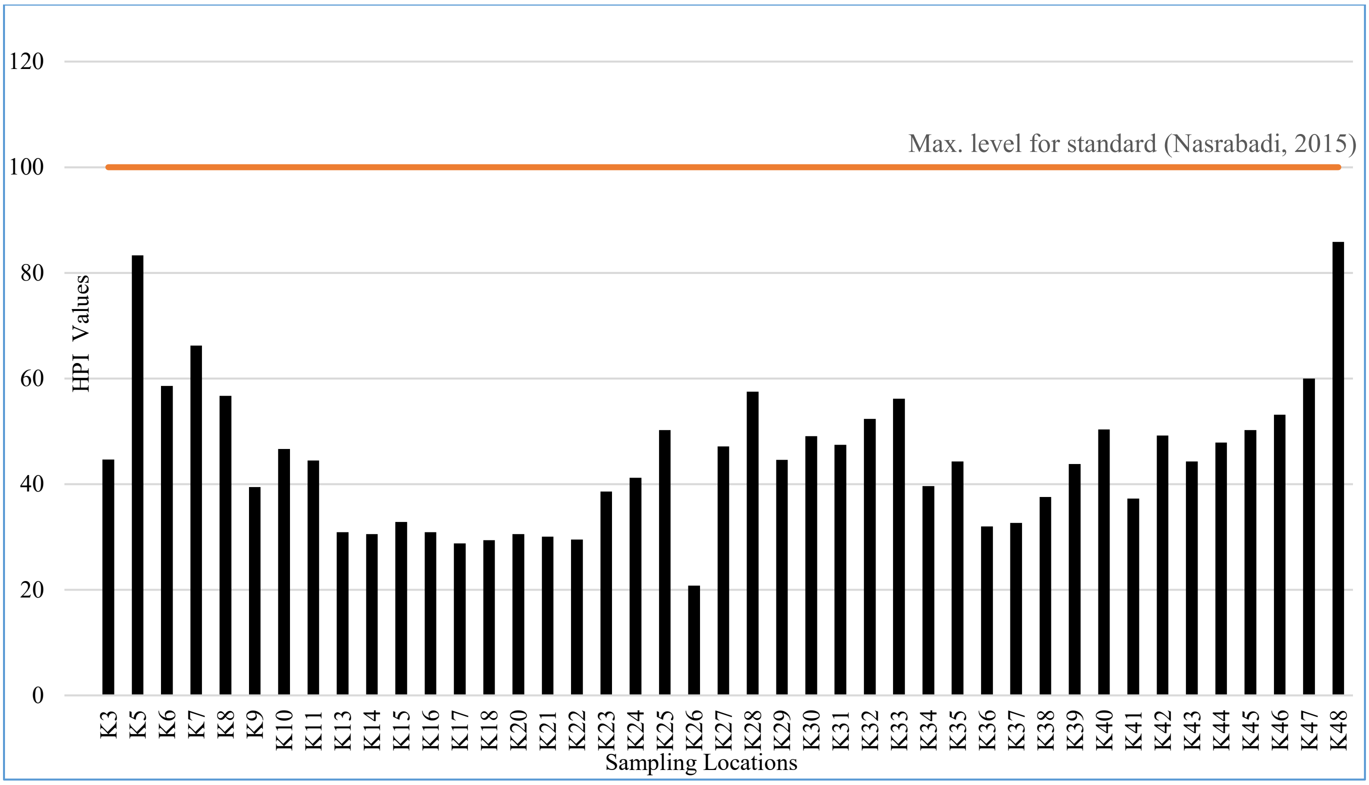

Figure 2. The Values of HPI in Different Locations.

Table 2. Status categories of HPI.

HPI	Quality of water (Sirajudeen et al., 2014)	Stations of study area
0-25	Very good	K26,
26-50	Good	K3, K9, K10, K11, K13, K14, K15, K16, K17, K18, K20, K21, K22, K23, K24, K25, K27, K29, K30, K31, K34, K35, K36, K37,K38, K39, K40, K41, K42, K43, K44, K45
51-75	Poor	K6, K7, K8, K28, K32, K33, K46, K47,
Above 75	Very poor (unsuitable for drinking)	K5,K48

CONCLUSIONS

The maximum anomaly value is 85,833 and it is observed in K48 location. The minimum one is 20,7686 which is measured in K26 location. HPI values of locations generally show two different anomalies in two different regions. HPI values generally show an increasing anomaly in both regions. The highest HPI value in the first region, between K1 and K11, is observed in location K5; and the highest HPI value in the second region, which is between K13 and K48, is K8. The factors that change the HPI value in both regions may be different. While the source of anomalies in first region may be the effects of dam; in second region may be agricultural activities.

The water quality of K6, K7, K8, K28, K32, K33, K46, K47 were determined as "poor"; K5 and K8 as "very poor". In these locations, it will be useful to avoid using water to avoid heavy metal effects. The water quality in K26 was identified as "very good"; the water quality in the remaining locations were outlined as "good".

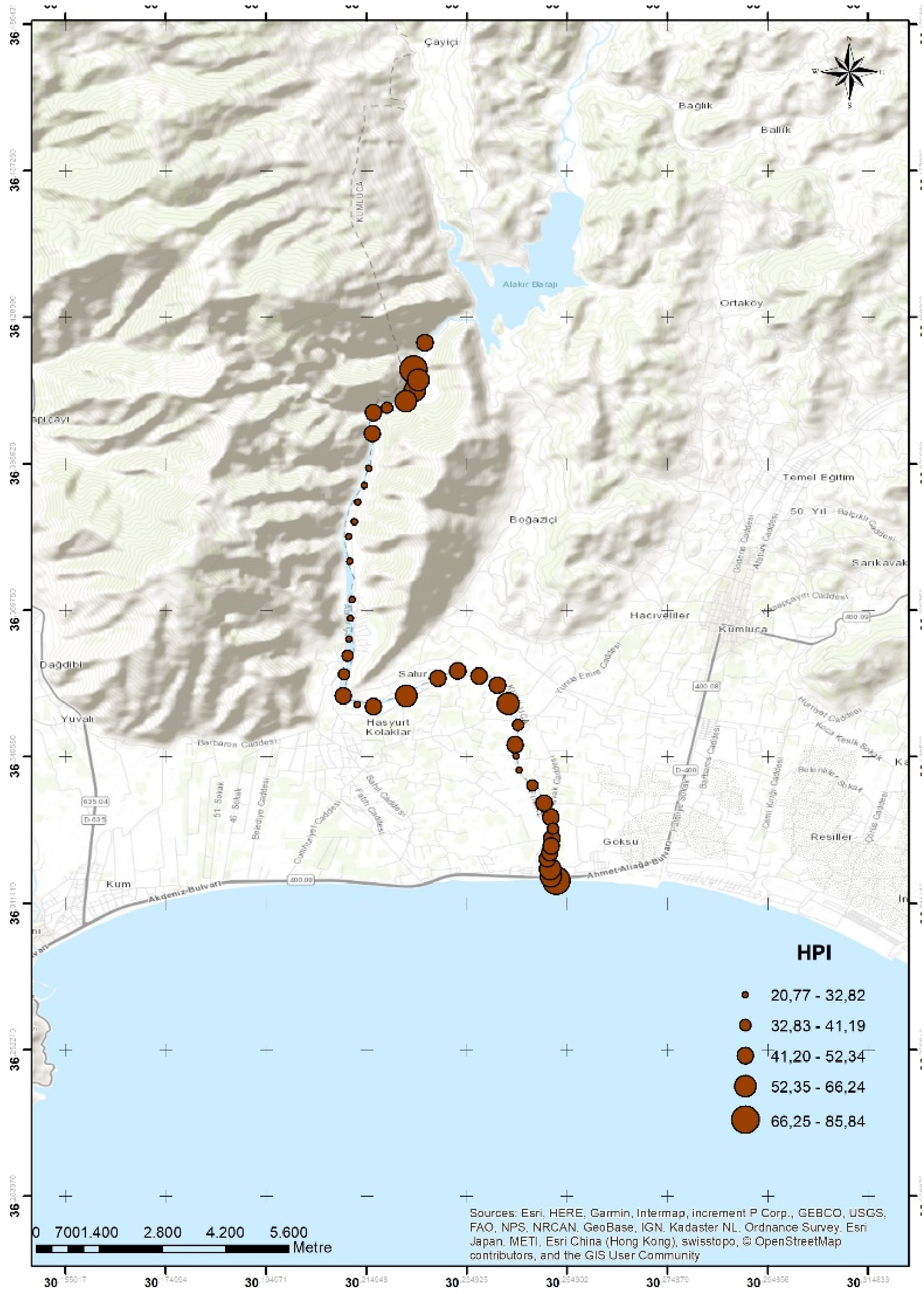

Figure 3. The Distribution of HPI Values.

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ORCID

Yasemin LEVENTELI *http://orcid.org/0000-0003-3714-4131*
Fusun YALCIN *http://orcid.org/0000-0002-2669-1044*