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RESEARCH ARTICLE

ENVIRONMENTAL BURDEN BY TOTAL SEDIMENT DUSTIN THE CITY OF ZENICA

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Abstract

The city of Zenica belongs to one of the most important industrial centers in Bosnia and Herzegovina. Due to the presence of industrial plants, especially metallurgical plants, but also due to a large number of small home fireplaces and the geographical location, air pollution in the Zenica valley is very high. Through continuous and dedicated air quality measurement, excessive air pollution was determined in the urban area of Zenica, i.e. limit values for total sediment dust were exceeded in some parts of the Zenica valley. The paper provides an analysis of the results of monitoring the total sediment dust and the content of heavy metals such as lead, cadmium, zinc, and iron in the total sediment dust for the period 2019-2021to determine the environmental burden and the average annual and maximum monthly trends of the total sediment dust in the Zenica valley. The analysis shows that emissions originating from industrial sources significantly burden the environment with sediment dust, especially in the zone up to about 3.5 km from the sources located in the industrial zone of the Zenica valley.

Introduction:-

Pollution is defined as the introduction by humans, directly or indirectly, of matter or energy into the environment that causes harmful consequences for living resources, i.e. danger to human health. Monitoring of the total sediment dust and the content of heavy metals in the sediment dust aims to determine the level of pollution of the ambient air and ecosystem with dust and heavy metals in the dust emitted from industrial plants in the wider area of the City of Zenica. The Zenica Basin, in which the City of Zenica is located, is exposed to the influence of increased emissions of various pollutants that originate primarily from metallurgical plants, but also other sources of environmental pollution (small house stoves, boilers, traffic, etc.). In such industrial-urban areas, it is of great importance to monitor the environment's state due to the long-term burden on the environment and the increased content of heavy metals in the air and soil, all to protect the vegetation and the health of the population. According to the Action Plan for Air Quality Protection in the Zenica-Doboj Canton, the air quality in the Zenica agglomeration is category III based on the concentration of total suspended particles and total sediment dust [1].

In order to preserve the protection of vegetation and ecosystems, and indirectly to protect the health of the population, limit values of total sedimentary dust (TSD) and the content of heavy metals in TSD in the ambient air have been prescribed. Table 1 gives limit values of the amount of total sediment and the content of heavy metals in

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total sediment according to the Rulebook on the manner of monitoring air quality and defining the types of pollutants, limit values, and other air quality standards ("Official Gazette of the FBiH", no. 01/12, 05/19 and 3/21).

Table 1:- Limit values of the amount of total sediment and the content of heavy metals in the sediment [2].

Pollutant	Sampling period	Average annual value ($mg/m^2.d$)	High values ($mg/m^2.d$)
TSP (total sediment dust)	One month	**200**	**350** *
Lead (Pb) in TSP	One month	**0,1**	-
Cadmium (Cd) in TSP	One month	**0,002**	-
Zinc (Zn) in TSP	One month	**0,4**	-
Titanium (Ti) in TSP	One month	**0,02**	-
Arsenic (As) in TSP	One month	**0,004**	-
Nickel (Ni)) in TSP	One month	**0,015**	-
Mercury (Hg) in TSP	One month	**0,001**	-
*Note: refers to the month of the year with the highest values of deposition/sediment			

Total sedimnet dust consists of all substances in a solid, liquid, or gaseous state that is not an integral part of the atmosphere, and are deposited on the ground by gravity or washing with precipitation. Large particles that are too heavy to be retained in the air and transported over long distances prevail in the sediments. These particles are deposited near the source of emissions, depending on the speed and direction of the wind and air humidity. The deposition of particles also depends on their size, density, and temperature, as well as the velocity of emission from the pollution source. However, the direct impact on human health is not pronounced because the particles of the total deposited matter are too large to be able to enter the human body by inhalation (Figure 1) [3].

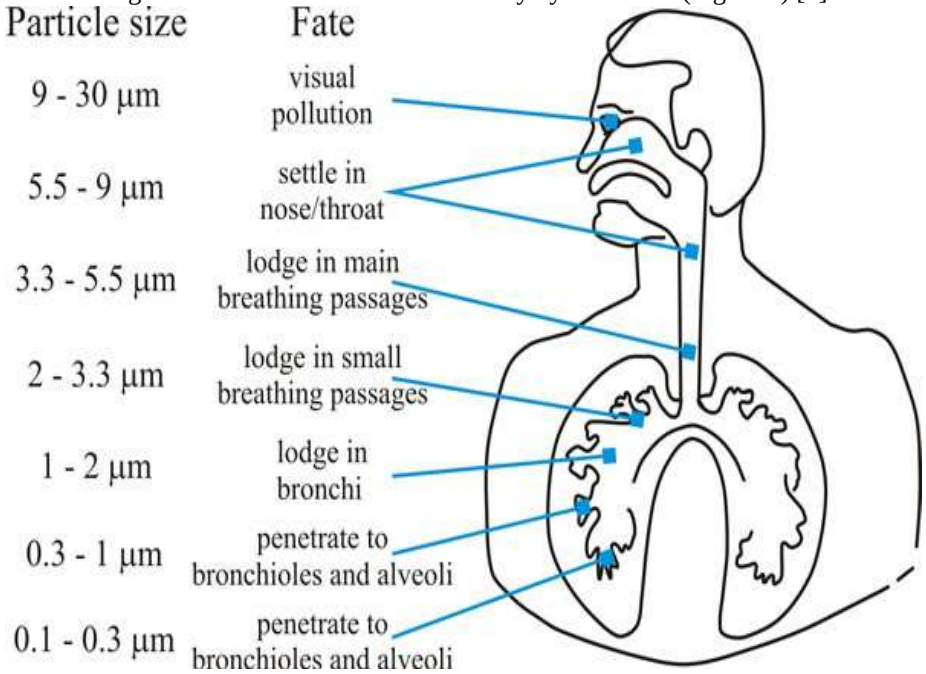

Figure 1:- The entry of particles into the respiratory system depends on the particle diameter [3].

The total sediment dust is a measure of visible pollution of the environment (dust that settles on windows, cars, and other surfaces). Dust on the leaves of plants can block the stomata and make it difficult for them to breathe, and in the presence of moisture, the particles can dissolve and enter the plants through the covering tissue. Deposition of the land leads to soil and groundwater pollution, thereby indirectly endangering human health [4].

Work Methodology:-

Due to the large number of sources of air pollution in the wider area of the City of Zenica, continuous monitoring of air quality has been established to monitor state of air quality. This monitoring of air quality is entrusted to the

Institute "Kemal Kapetanović" in Zenica. Based on the measurement data, the Institute prepares reports for the government sector, non-governmental organizations, and citizens of the city of Zenica [5].

Collection of samples of total sediment dust in the area of the Zenica valley is carried out at 13 locations. Table 2 gives an overview of the sampling locations, and Figure 2 shows the spatial distribution of the sampling locations along the Zenica valley.

Table 2:- Overview of sampling locations of total sedimentary matter in the wider area of the Zenica basin.

Sampling site designation	Location address	Zone	Geographical coordinates	Altitude m a.s.
0 - Institut	Travnicka 7	City	E 44° 11' 59"; N 17° 54' 08"	327
1 - Centar	Tetovska	City	E 44° 13' 57"; N 17° 53' 11"	341
2 - Raspotocje	Mejdandzik	Suburban area	E 44°11’52"; N 17°54’34’’	325
3 - LukovoPolje	Sarajevska	Suburban area	E 44°11’15"; N 17°55’31"	321
4 - Perin Han	Gorazdanska bb	Rural area	E 44° 11' 23"; N 17° 56' 41"	322
5 - Crkvice	Marjanovica put	City	E 44° 12' 14"; N 17° 55' 41"	354
6 - Kamberovici	Bistua nova	City	E 44° 11' 07"; N 17° 58' 14"	361
7 - Pehare	Kamberovicacikma	Suburban area	E 44° 12' 24"; N 17° 55' 00"	314
8 - Ricice	Pehare bb	Suburban area	E 44° 11' 08"; N 17° 58' 12"	354
9 -D.Gracanica	Ricicki put	Suburban area	E 44° 13' 21"; N 17° 54' 51"	334
10 - Banlozi	Vranducka	Rural area	E 44° 13' 47"; N 17° 54' 27"	315
11 - Tetovo-1	Tetovo bb	Suburban area	E 44° 13' 42"; N 17° 53' 18"	343
12 - Tetovo-2	Banlozi bb	Suburban area	E 44° 15' 01"; N 17° 53' 41"	309

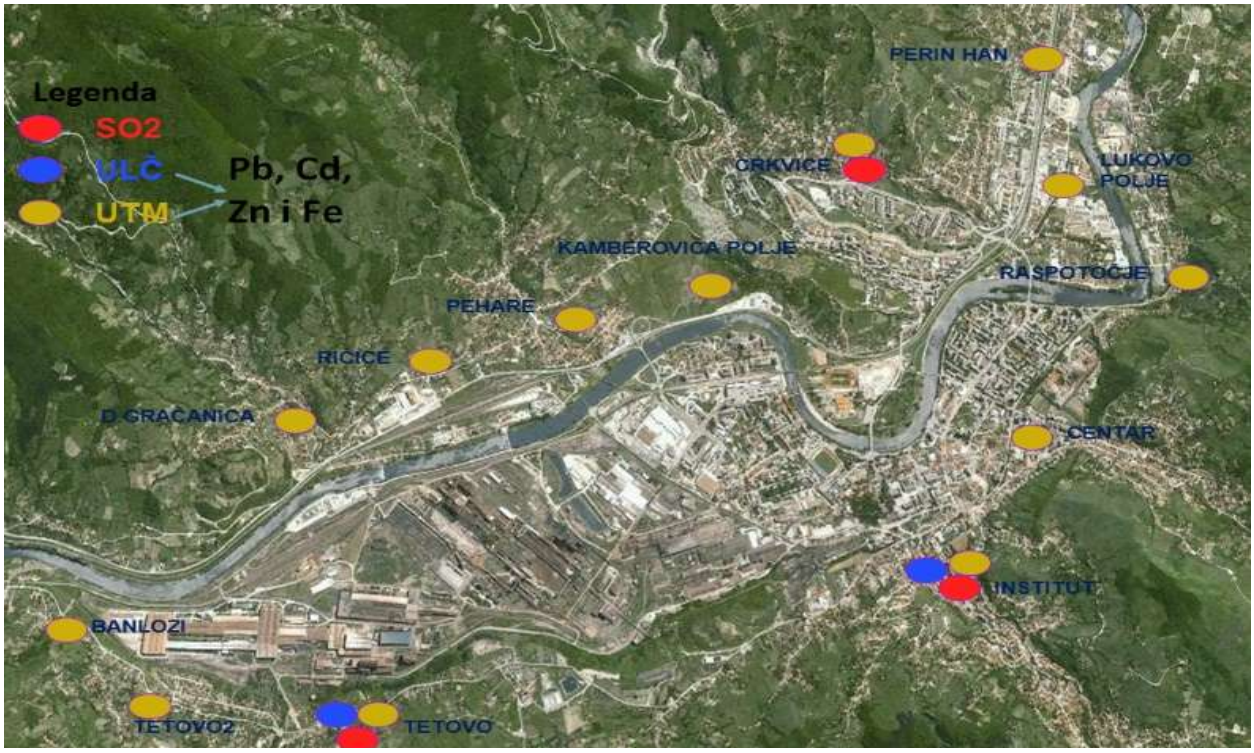

Figure 2:- Sampling locations of total sediment dust in the Zenica valley.

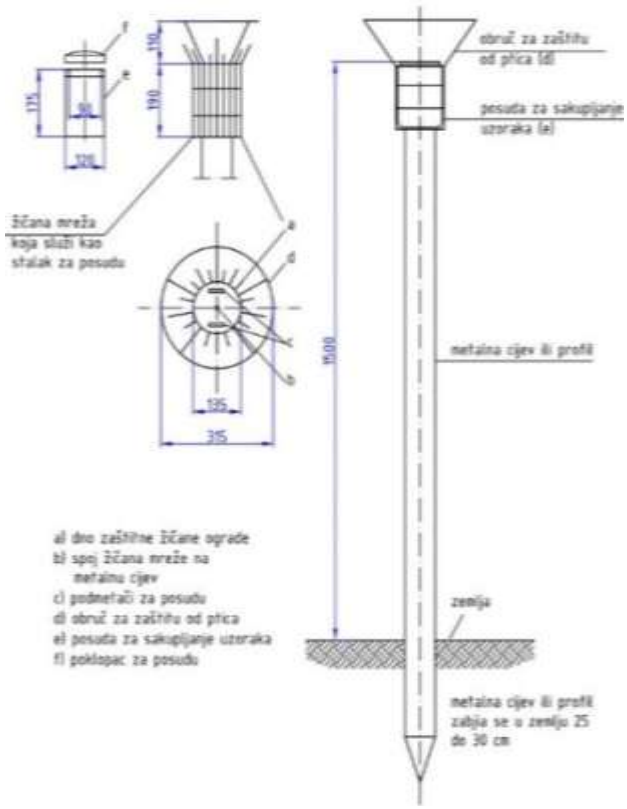

Figure 3:- Bergerhoffsedimentator.

At each sampling location a Bergerhoffsedimentator was installed by VDI guidelines 2119, sheet 2. (Guidelibyation of German Engineers, 1972 - total sediment [6]. Bergerhoff's device for collecting total sediment dust consists of a container for collecting samples and a stand with a protective wire mesh that serves to house the container and protect it from birds (Figure 3). Samples collect monthly and total sediment dust is determined gravimetrically. The content of lead, cadmium, zinc and iron in the settling powder is determined using atomic absorption spectrophotometry.

Monitoring Results Of Sediment Dust And Heavy Metals Content

The following table provides an overview of the maximum and average annual values of the amount of total sediment in the wider area of the City of Zenica for the period 2019-2021. Based on the results of the measurement, it can be seen that the permitted limit value for high concentrations and average annual concentrations of total sediment dust was exceeded at all measurement sites, especially at the sites located in near the metallurgical plants of the Zenica industrial zone(Tetovo-1, Tetovo-2, and Banlozi). The largest amount of sediment dustwas measured at the measuring site Tetovo-1 in 2019 when the average annual value of total sediment dust was 836 mg/m^2 day, and the maximum monthly value was 2227 mg/m^2 day. The results also show a significant increase ofsediment dustat the measuring site Pehareduring the observed monitoring period. By analyzing the results from the previous period and the possible causes of the increase of sediment dust in the period 2019-2021, it was concluded that construction works on Zenica-Nemila highway section caused this increase. This measuring site is located near the access road to the construction sites of this section, which is passed daily by a large number of heavy trucks.Moreover, due to the inadequate maintenance of the access road, the re-emission of dust on this section is significant.

Table 3:- Overview of the maximum and average annual values of the amount of total sediment in the wider area of the City of Zenica for the period 2019-2021(mg/m^2.day).

Measurement site designation	**2019**		**2020**		**2021**	
	Month	**Year**	**Month**	**Year**	**Month**	**Year**
0 - Institut	696	383	753	418	990	419

1 - Centar	744	324	771	367	599	374
2 - Raspotocje	739	440	1084	400	676	347
3 - LukovoPolje	994	478	1100	474	646	341
4 - Perin Han	566	290	812	374	656	321
5 - Crkvice	557	323	764	262	486	276
6 - Kamberovici	730	403	645	348	877	545
7 - Pehare	1214	657	1467	794	1176	700
8 - Ricice	888	526	782	462	727	473
9 – D. Gracanica	649	505	634	452	1678	577
10 - Banlozi	754	525	1161	670	967	460
11 - Tetovo-1	2227	836	1380	652	1317	551
12 - Tetovo-2	1200	683	919	651	2013	738
Threshold value	**350**	**200**	**350**	**200**	**350**	**200**

The following figure shows a graphic representation of the average annual values of the amount of total sediment dust in the Zenica valley for the period 2019-2021.

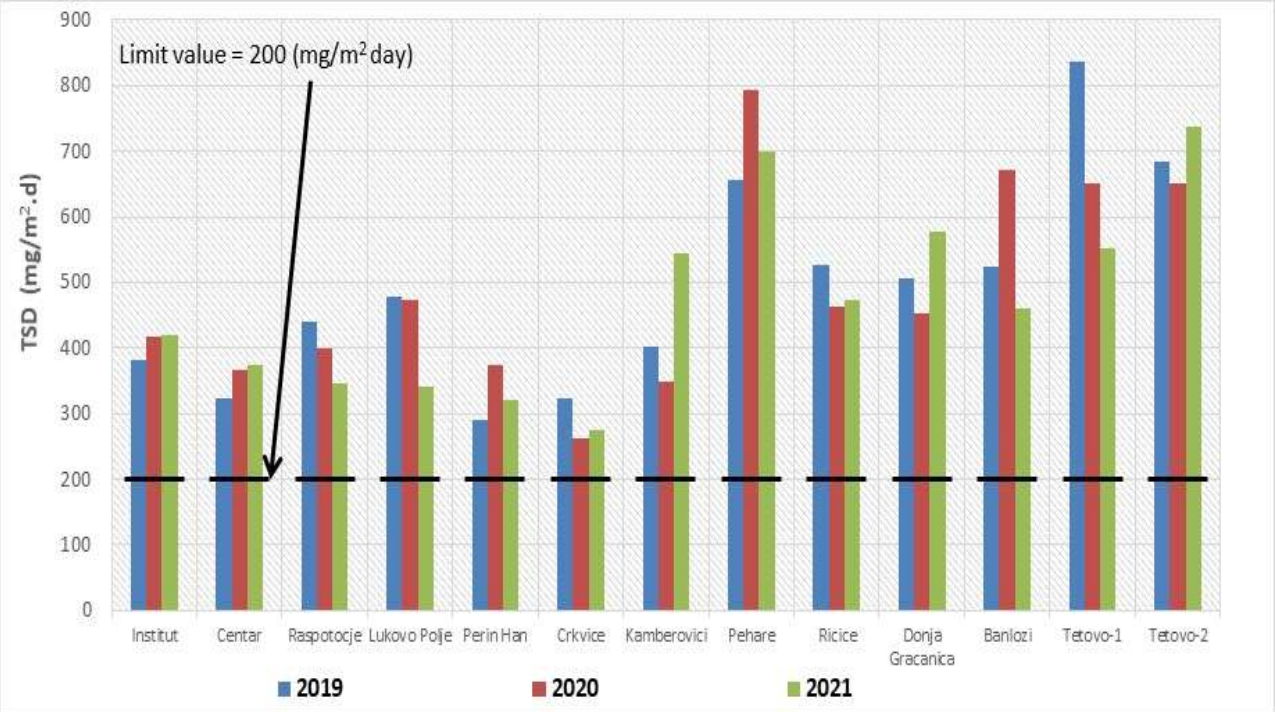

Figure 4:- Graphical presentation of the average annual values of the amount of total sediment in the Zenica valley for the period 2019-2021.

The following figure shows the maximum monthly values of the amount of total sediment in the Zenica valey for the period 2019-2021. According to the current regulations, it is allowed that the high value of the amount of total sediment dust(350 mg/m^2 day) is exceeded only one month of the year. However, the results of the monitoring show that the high value of the total sediment dusthas been exceeded for an average of 6 months, depending on the measurement site and the measurement period.

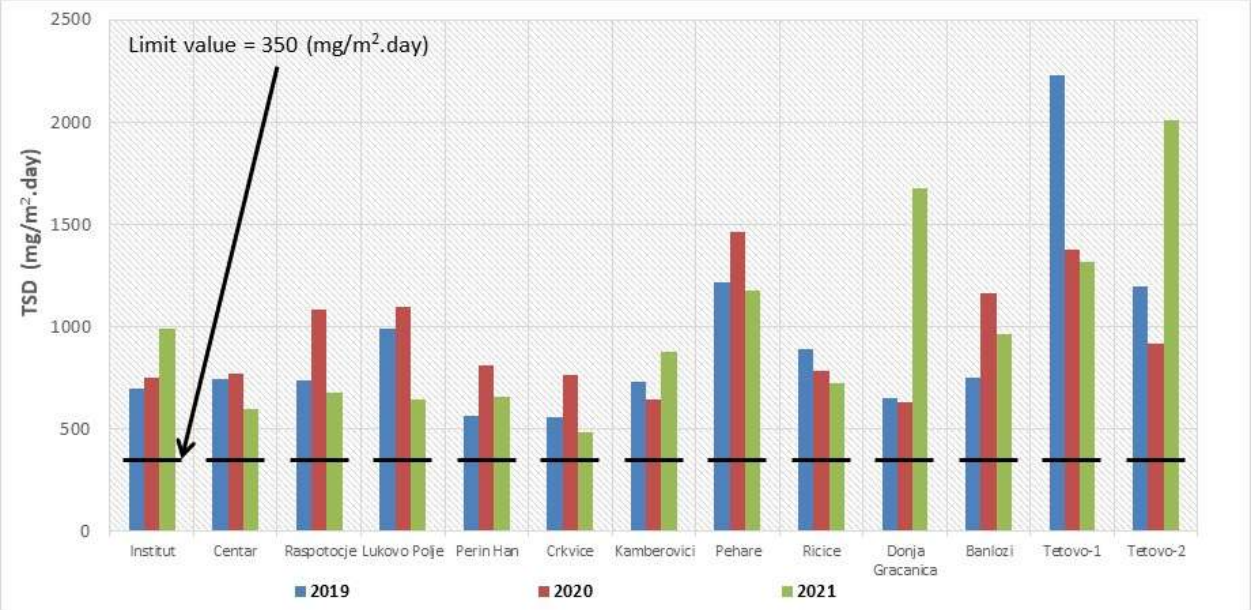

Figure 5:- Display the maximum monthly values of the amount of total sedimentin the Zenica valley for the period 2019-2021

The following table shows the results of the analysis of heavy metals (Pb, Cd, Zn, Fe) in the sediment dust.

Table 4:- Overview of concentrations of Pb, Cd, Fe, and Zn in the total sediment dust in the area of the Zenica valley for the period 2019-2021, and limit values of heavy metals in total sediment dust

Designation of sampling measurement points	**2019**				**2020**				**2021**			
	Pb	**Cd**	**Fe**	**Zn**	**Pb**	**Cd**	**Fe**	**Zn**	**Pb**	**Cd**	**Fe**	**Zn**
0 - Institut	0,038	0,0024	45,48	0,148	0,023	0,0026	46,34	0,097	0,025	0,0095	46,31	0,182
1 - Centar	0,030	0,0014	10,04	0,078	0,051	0,0023	8,035	0,071	0,022	0,0016	7,624	0,116
2 - Raspotocje	0,041	0,0037	42,91	0,128	0,021	0,0020	28,25	0,064	0,014	0,0012	21,80	0,094
3 -Lukovopolje	0,047	0,0024	53,10	0,109	0,027	0,0016	51,27	0,067	0,018	0,0020	29,29	0,082
4 - Perin Han	0,045	0,0028	30,02	0,075	0,035	0,0012	36,15	0,044	0,018	0,0023	25,32	0,069
5 - Crkvice	0,038	0,0034	17,94	0,103	0,020	0,0041	23,52	0,043	0,020	0,0031	25,07	0,106
6 - Kamberovic	0,133	0,0052	63,44	0,142	0,023	0,0032	53,81	0,057	0,024	0,0063	98,04	0,136
7 - Pehare	0,040	0,004	114,1	0,175	0,054	0,0040	112,61	0,108	0,017	0,0024	54,44	0,183
8 - Ricice	0,059	0,0039	56,91	0,205	0,061	0,0027	35,05	0,140	0,028	0,0027	29,32	0,197
9 - D.Gracanica	0,065	0,0042	76,63	0,253	0,068	0,0038	61,69	0,163	0,045	0,0040	60,24	0,254
10 - Banlozi	0,084	0,0058	94,21	0,322	0,116	0,0045	102,18	0,197	0,107	0,0019	47,08	0,197
11 - Tetovo-1	0,221	0,0072	96,13	0,558	0,121	0,0060	68,30	0,446	0,046	0,0029	50,16	0,395
12 - Tetovo-2	0,108	0,0057	105,69	0,622	0,115	0,0057	99,07	0,431	0,057	0,0046	87,50	0,717
Threshold value	**0,1**	**0,002**	**-**	**0,4**	**0,1**	**0,002**	**-**	**0,4**	**0,1**	**0,002**	**-**	**0,4**

Figure 6 shows a graphic representation of average annual lead concentrations by measuring sites for the period 2019 - 2021. It can be seen from the picture that the permissible limit values for lead were exceeded at the measuring points located near metallurgical plants (measuring sitesBanlozi, Tetovo-1 and Tetovo-2). These measuring sites are located in the settlements of Tetovo and Banlozi and are exposed to high dust emissions from the Basic oxygen furnace located in its immediate vicinity. The cause of the increased lead concentration at the measuring site "Kamberovici" in 2019 is still unknown.

Figure 7 shows a graphic representation of the average annual concentrations of cadmium for the period 2019 - 2021. It can be seen from the figure that the permissible limit values for lead were exceeded at eight measuring

points distributed along the entire Zenica valley. It is evident from the picture that the level of cadmium in the total sediment dust has a statistically significant downward trend at most measuring points.

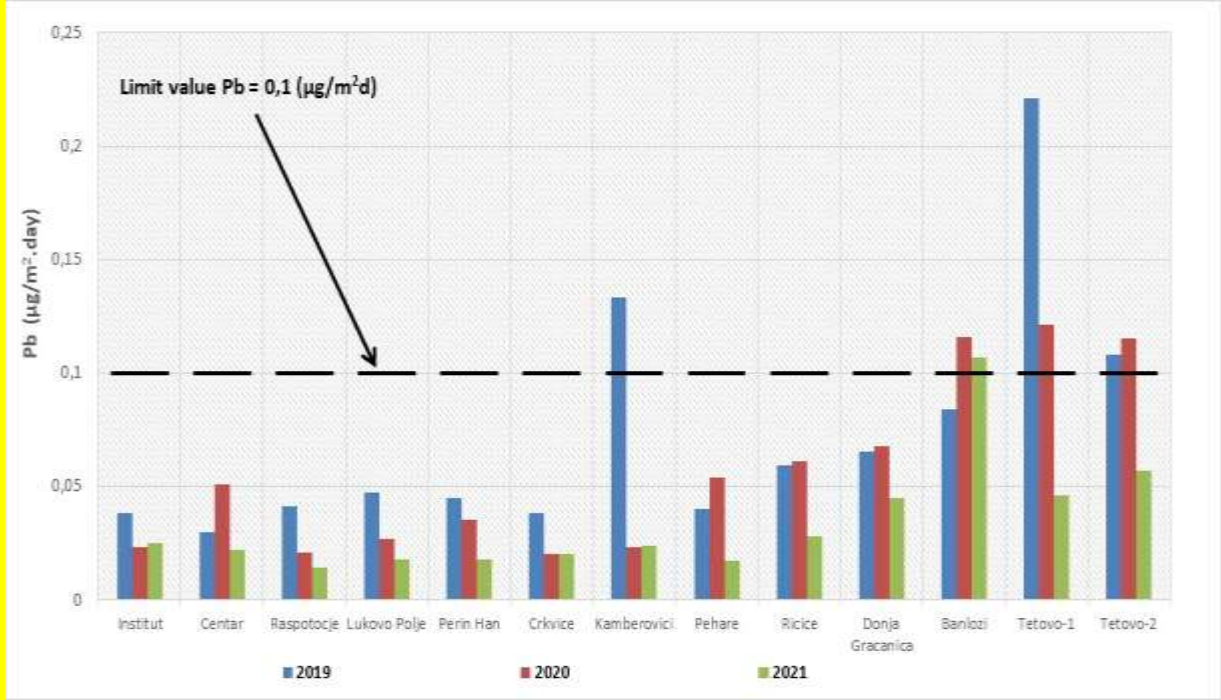

Figure 6:- Lead content in total sediment dust for the period 2019 – 2021.

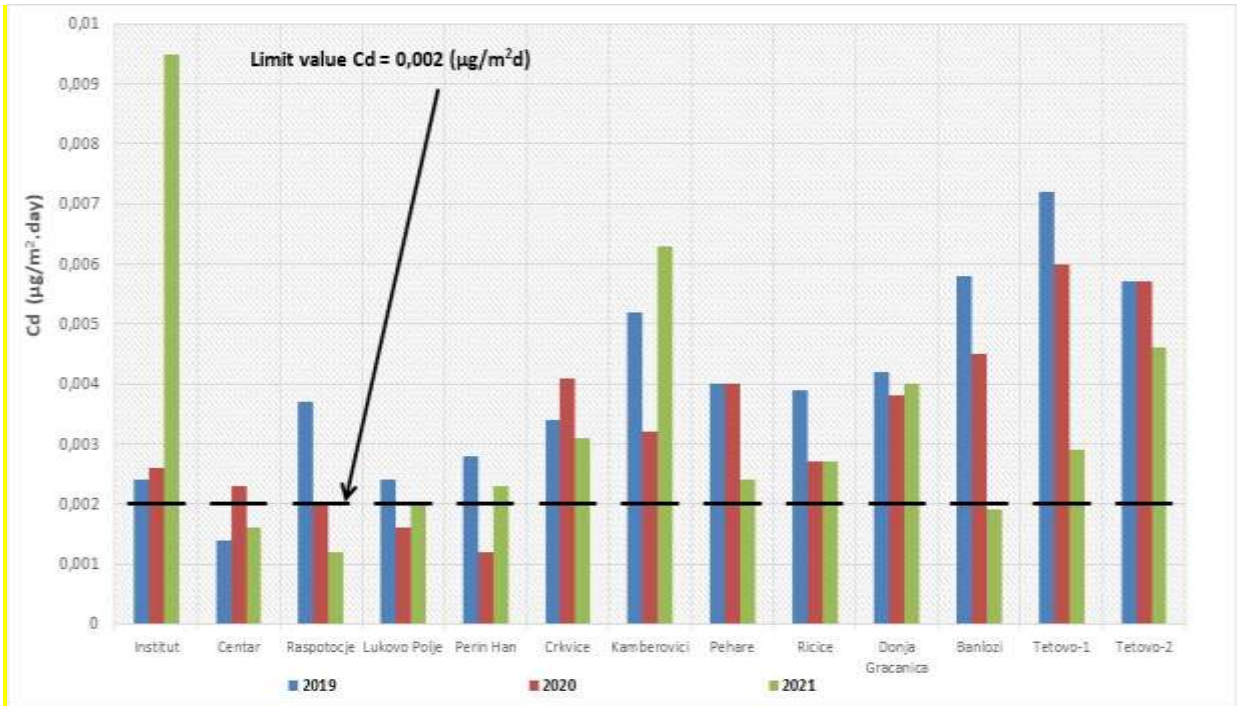

Figure 7:- Cadmium content in the total sediment for the period 2019 - 2021.

Figure 8 shows a graphic representation of average annual concentrations of zinc in total sediment dust.The image clearly shows the increase in the zinc content in the sediment as it approaches the metallurgical plants of the Zenica industrial zone. At the measuring locations closest to these facilities, the permissible values of zinc concentration in the total sediment dust (Tetovo-1 and Tetovo-2) were exceeded.

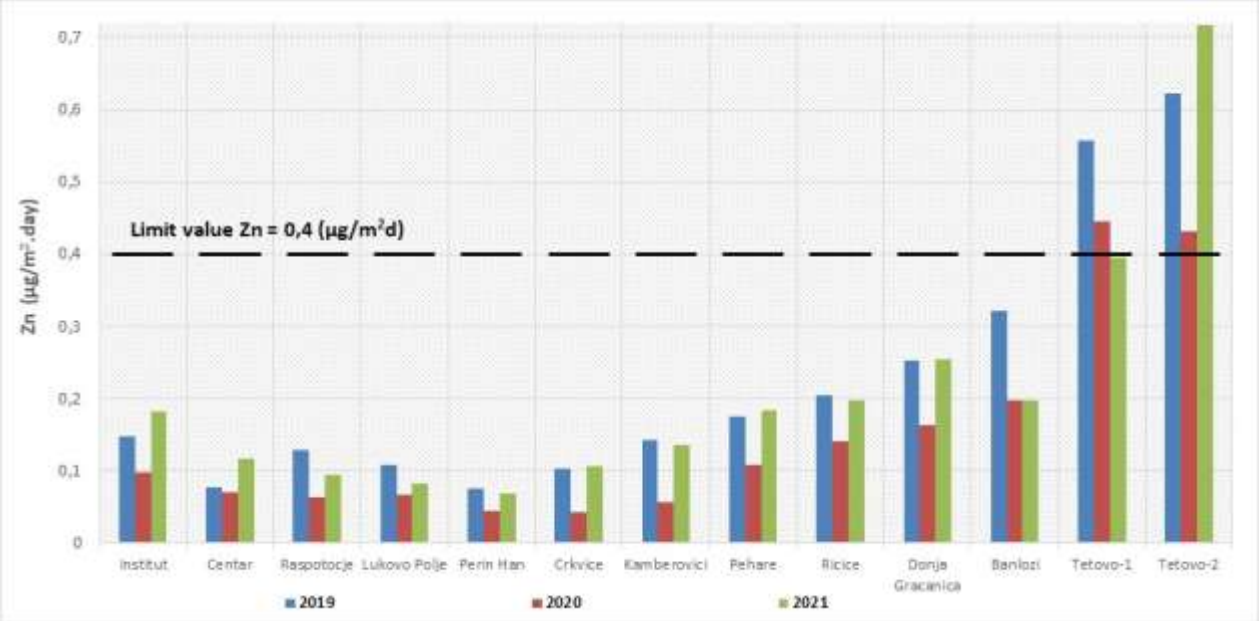

Figure 8:- Zinc content in the total sediment for the period 2019 - 2021.

The results of monitoring show increased concentrations of iron in places around metallurgical plants, but also a trend of decreasing concentrations of iron in the total sediment in the past 3 years at almost all measuring places, especially in the settlements of Tetovo and Banlozi, which are the closest to the metallurgical plants.

Conclusion:-

The monitoring of the total sediments produced by atmospheric deposition is one of the most important mechanisms for controlling pollutants present in the air and evaluating the effects of projects to improve air quality through the reduction of dust emissions, especially from industrial sources.

Monitoring of the total sediment dust in the Zenica valley in the period 2019-2021 shows an exceedance of the annual limit value of the amount of total sediment dust and the maximum allowed amount of total sediment dust at all measuring sites, especially at places located near the metallurgical plants of the Zenica industrial zone. Exceeding lead and zinc concentrations were also registered at the measuring sites that are under the direct influence of metallurgical plants while exceeding the cadmium content was registered at almost all measuring points.

The data show a trend of decreasing concentrations of lead, cadmium, and iron in the total sediment dust, especially at the measuring points around the industrial zone of Zenica, and at the measuring points that are under the direct influence of metallurgical plants.

Literature:-

[1]Air Quality Protection Action Plan for the Zenica-Doboj Canton, UNZE OJ Institute "Kemal Kapetanovic" in Zenica, 2020;
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[4]Hršak, J. and Balagović, I.: Content of lead, cadmium and thallium in sediment in Zagreb in the period 1998-2004, ZborniksažetakaZaštitazraka 05, Zadar, 2005, 258-262;
[5]Reports on measuring air quality in the City of Zenica for 2019, 2020, and 2021, "Kemal Kapetanović" Institute in Zenica;
[6]Standard VDI 2119, Blatt 2 (Guidelines of the "Asso, citation of German Engineers, 1972 - total sediment).