HEAVY METALS IN LIGNITE OF THE KOSTOLAC-KOVIN AND KOLUBARA BASINS, SERBIA – BAD TOXIC OR GOOD TOPIC – A BIG NUMBERS GAME

Expert Paper
DOI: 10.5937/RGD240031V

Vučković Bogoljub

Joint stock company „Elektroprivreda Srbije", Kolubara coal basin, Serbia
bogoljub.vuckovic@bkolubara.rs

Abstract: *The Kostolac-Kovin lignite basin, in eastern Serbia, with an area of 320 km^2, with 5 separate layers of lignite and with a total of about 5.7B tons of geological resources and reserves represents an exceptional potential for lignite production in Serbia. Also, the Kolubara lignite basin, in western Serbia, with an exploitable area of about 200 km^2, with 3 separate lignite layers and with a total of about 4.1B tons of geological resources and lignite reserves represents a proven potential for lignite production in Serbia. In total, we own nearly 10B tons of geological resources and lignite reserves in both lignite mining areas. The underground mining activities in both areas start at late XIX century, respectively. Open pits run since early 50s of the XX century, and still is ongoing. About 1.7B tons are already dug out in both areas. Almost all of that dug out masses (up to 99%) were combusted in own thermo energetic plants; combusted coal now seat as a ash in amounts of 350M t in ash accumulations.*

The lignite resources listed in this way are not fully exploitable, but they represent potential for consideration. In this work, we deal with the geochemical characteristics of lignite seams in both lignite basins and analyze the possible value of selected strategic metals found in lignite. What we as authors and you as readers are most interested in is whether heavy metals from lignite are at the same time strategic metals that can have economic value. In the following chapters we will deal with this issue.

Key words: LIGNITE, TOXIC, STRATEGIC, METALS, ECONOMIC VALUE

GENERAL INFORMATIONS
LIGNITE BASIN KOSTOLAC-KOVIN (EAST SERBIA)

Generally, the lignite basin is located in eastern Serbia, on 60 km east of Belgrade, between Velika Morava and Mlava rivers, which flow into the Danube in that area (figures 1 and 2).

Figure 1, General geographical position of the Kostolac-Kovin and Kolubara lignite basin, red circles - position of the lignite basins; left- Kolubara Lignite Mines, right – Kostolac Lignite Mines

It is divided into two parts by the Danube - to the south is the Kostolac Basin, and to the north of the Danube is the Kovin Basin (Figure 2). Geological explorations began in 1941. and continues to this day. In total, 3,900 boreholes were drilled in last 80 years, i.e. 305,000 m of drilling (Figure 2). The 5 lignite layers are generally not definitively contoured either laterally or in depth, but there is a potential for their further research outside the existing exploration fields. The general calculation of lignite resources for all 5 lignite seams yielded about 5,7B t of lignite.

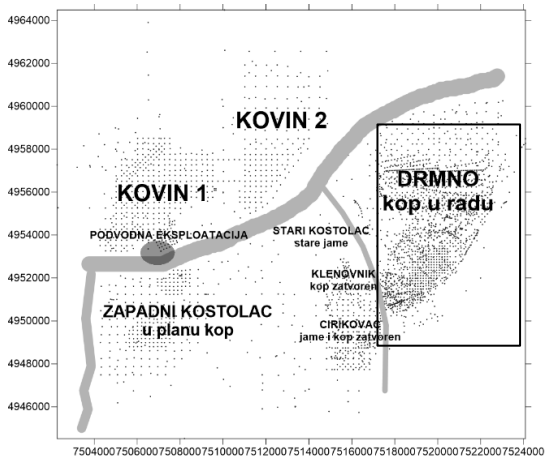

Figure 2, General overview of exploration drill holes (black dots) for the period 1941-2023. year in the Kostolac-Kovin lignite-bearing basin, blue thick line – river Danube, blue thin line left – river Velika Morava, blue thin line center – river Mlava, gray circle - underwater mining of Kovin lignite; blue square - OP Drmno under running

LIGNITE BASIN KOLUBARA (WEST SERBIA)

The lignite basin is located in western Serbia, on 60 km southwest of Belgrade, in Kolubara alluvial river basin, which flow into the Sava river (Figures 1 and 3).

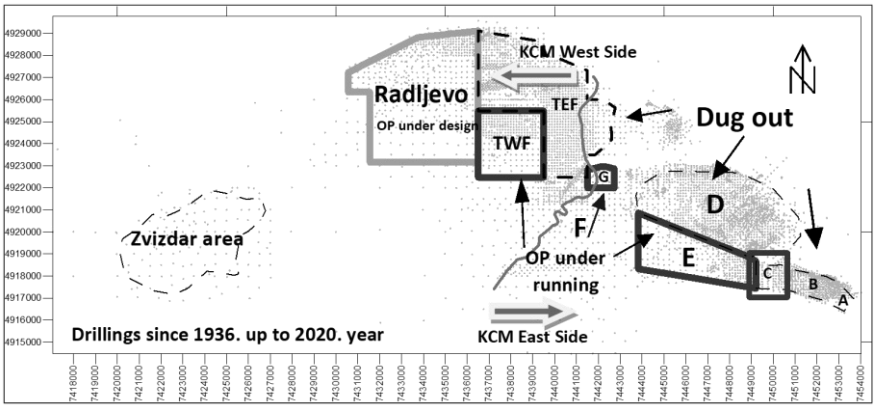

Figure 3, KCM[1] operational area, drill-holes since 1936. year; total >7,500 holes, e.g. 605,000 m of core drilling; curved line – river Kolubara divide area on East and West side

Whole period of geological surveys from 1936. up to 2023. in the geological and mining aspects is very successful. As a result, about 4,1B t of geological lignite reserves and resources were explored, as well as additional few hundred million m^3 resources of non-metallic mineral raw materials. Lignite exploration and exploitation began in the eastern part of the basin, where it is still ongoing, but is slowly moving to the western part of the basin, where it is becoming more important.

GEOCHEMISTRY OF LIGNITE, ACCOMPANYING SEDIMENTS AND TOP SOIL IN THE BASINS AREAS

In Kostolac-Kovin lignite basin numerous analyzes were taken to determine the quality of lignite, as well as numerous others for geotechnical and hydrogeological purposes. In the last ten years, special attention has been paid to the ecological characteristics of lignite, and the contents of HM[2] have also been determined. Apart from lignite, samples were also taken from all sediments in the horizontal and vertical profile of the deposit; as well as from the soil above the Drmno deposit and from gravel from the wider area [19-21].

In Kolubara Lignite Mines there are ecology explorations in a smaller scale. Most explored area relate with open pits surrounding top soil and some lignite layers [2, 12].

[1] *KCM - Kolubara Lignite Mines*
[2] *Heavy Metals*

TOXIC HEAVY METALS IN LIGNITE – PUBLIC AND EXPERT EXPECTATION OF ECOLOGY POLUTION

Of course, this topic is extremely hot and is present in all possible media, bureaus, offices, NGO and so on. Everyone's expectations are that the exploitation and combustion of lignite masses will extremely pollute the environment. This goes so far, that it has already become a kind of mantra. It is considered that the thermal energy sector of Serbia pollutes the environment to a great extent and that appropriate protection or remedial measures must be taken as a matter of urgency.

MEASURED DATA DOES NOT SHOW THAT

However, numerous measured data from surface lignite mines in Kostolac and Kolubara, as well as data on ash from related thermal power plants, do not indicate this. There are extremely numerous examples of soil pollution in the vicinity of various industrial zones throughout Serbia, the Region, Europe and the World [1-21]. Considering that this issue is extremely extensive, we only give a few characteristic examples (figures 4-8).

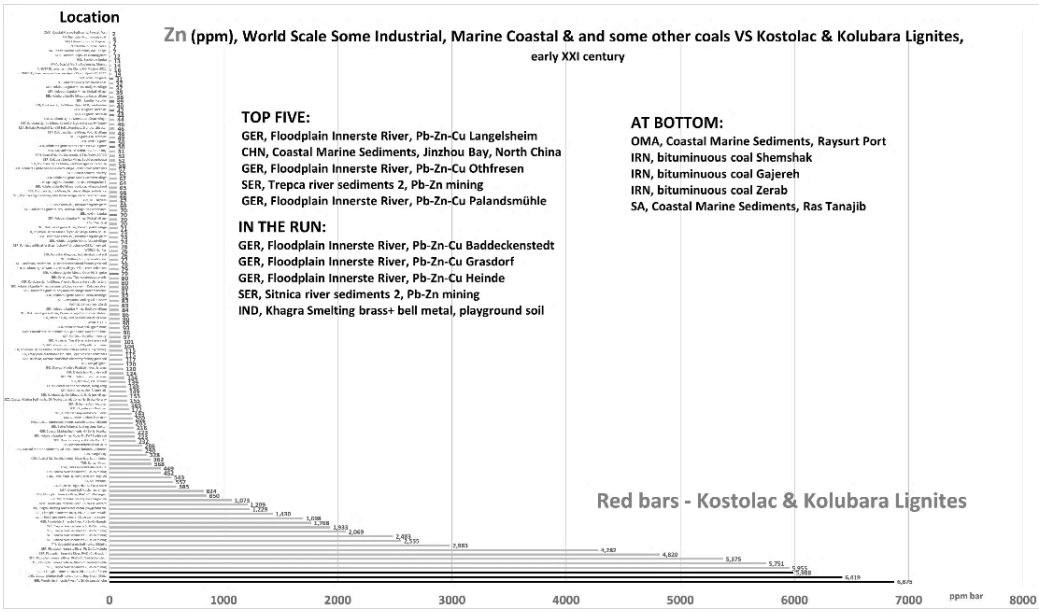

Figure 4, Zinc (Zn) concentrations in top soil of some industrial zones worldwide VS. Kostolac - Kovin and Kolubara lignites

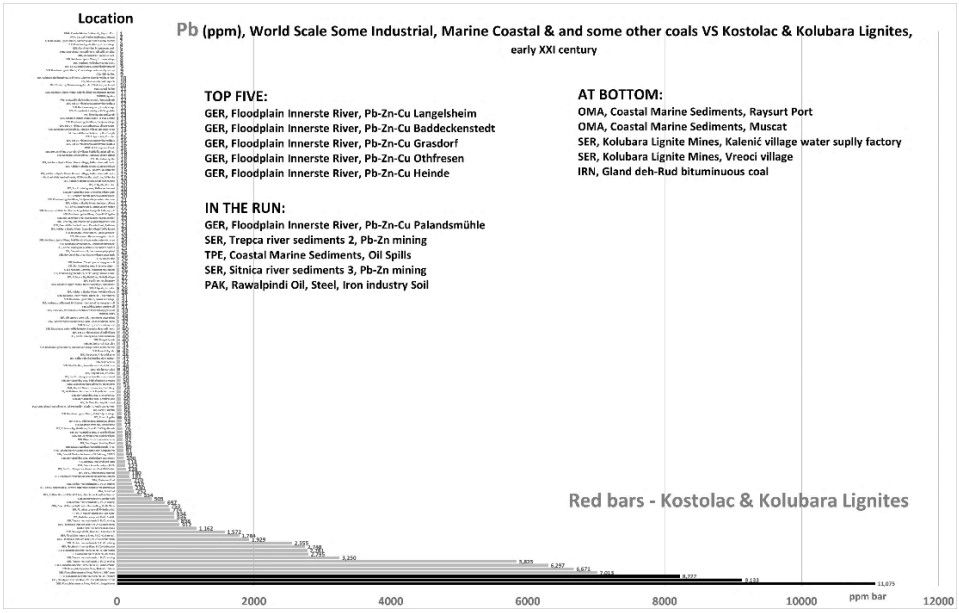

Figure 5, Lead (Pb) concentrations in top soil of some industrial zones worldwide VS. Kostolac - Kovin and Kolubara lignites

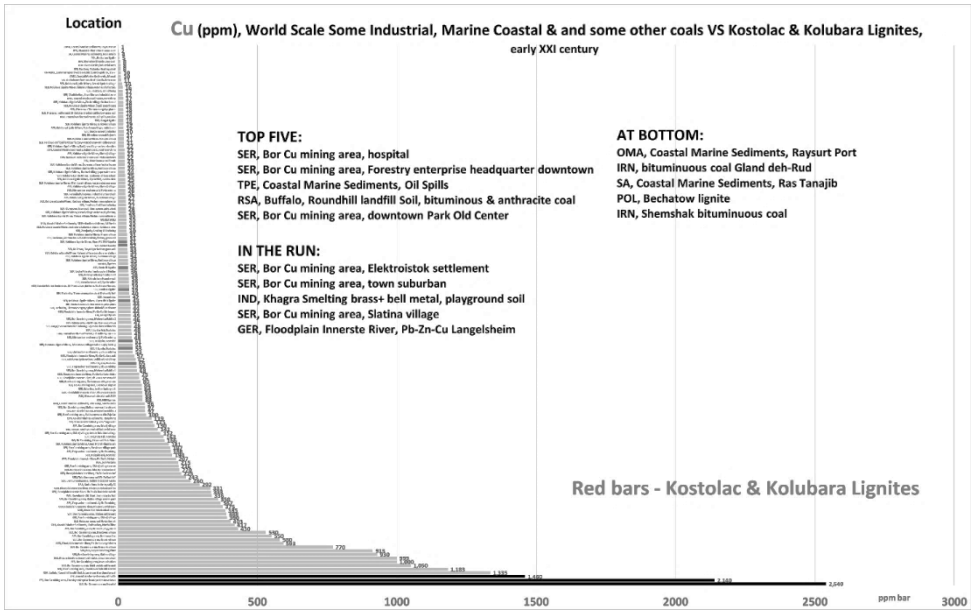

Figure 6, Copper (Cu) concentrations in top soil of some industrial zones worldwide VS. Kostolac - Kovin and Kolubara lignites

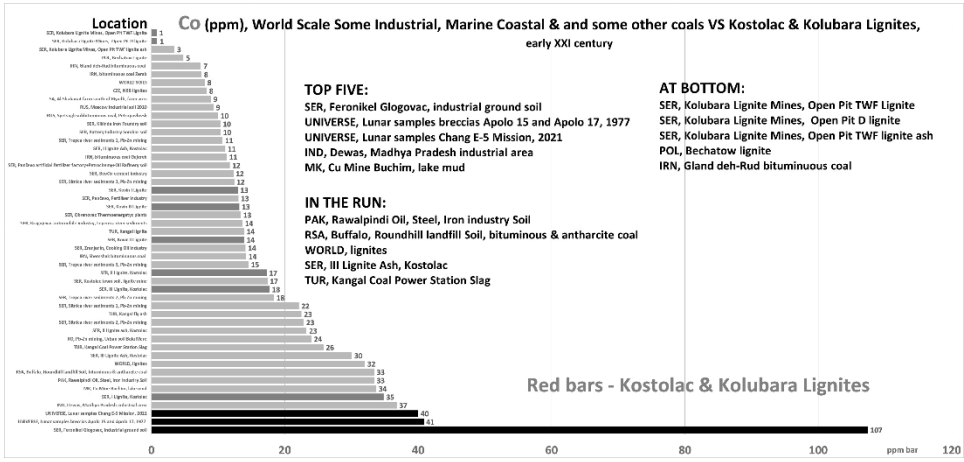

Figure 7, Cobalt (Co) concentrations in top soil of some industrial zones worldwide VS. Kostolac - Kovin and Kolubara lignites

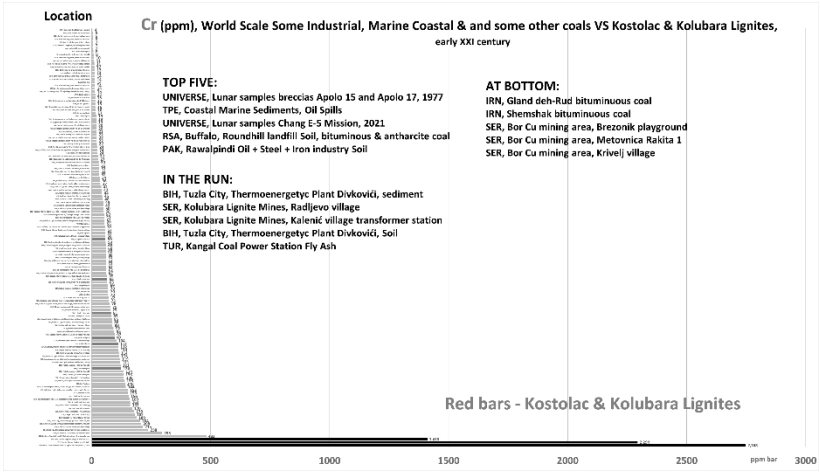

Figure 8, Chromium (Cr) concentrations in top soil of some industrial zones worldwide VS. Kostolac - Kovin and Kolubara lignites

As can be seen from the pictures shown, the red columns of our Serbian lignite are regularly in the lower category of pollution. This is especially evident for Zn or Pb contents. In some cases, extremely high soil pollution can be more than ten times greater than our general capabilities. Even, in several extreme examples, the contents are even 300 times higher. And what should we do now? Where are we in all of that? Are we doing something wrong or should we look for alternative solutions?

AND NOW WHAT
STRATEGIC MINERALS – WORLD GOVERNMENTS RUN

Recently, numerous world governments have declared an insatiable need for "strategic minerals". In this, the governments of the USA, EU, Japan, etc., lead the way. They actually know that the development of super high-tech technologies also requires reliability in the supply of strategic metals. For strategic metals, they announced more than thirty rare metals, rare earth minerals, transition metals, metalloids and some specific non-metals. Some of them were ‘’toxic’’ few months ago.
Numerous governments of "small" countries found themselves in the race with these "needs" of theirs, and they too are announcing that they now need all of this extremely. And that too "under urgency". Suddenly, toxic metals are no longer toxic, but quite acceptable, give them as much as possible, let's see in which mineral deposits they are found. Now it is popular to have as much Pb, Zn, Cu, Co, Ni, Cd, As, S, Be, La, and even U or Th, as well as numerous others.

Finally, we come to the very title and topic of this paper - which is whether the heavy metals present in the lignite have any economic value.

THE BIG NUMBER GAME

In order for these metals to be realistically worth anything at all, it is not only important to have them in measured concentrations, but also to have/design/develop extraction technology and at the end of the day get them as some kind of "metal bars". In fact, it is for sale.

Considering that we do not have the possible extraction technologies, we adopt their average calculated total concentrations in the lignite of both basins for consideration. Also, we deal with total quantities of lignite and total quantities of metals, with their $ value mostly taken from LME, even few from other specialized metal stock markets (figures 9-14).

KOSTOLAC-KOVIN LIGNITE AREA

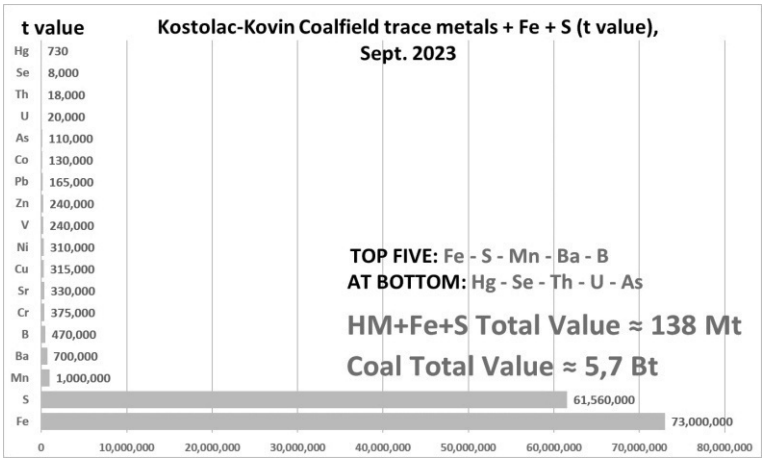

Figure 9, Mass value (t) of heavy metals from Kostolac-Kovin lignitefield, sept. 2023.

It can be observed that the relative weight share of the mentioned heavy metals is about 2.4% in relation to the total mass of wet lignite. It amounts to about 5% of the dry lignite mass.

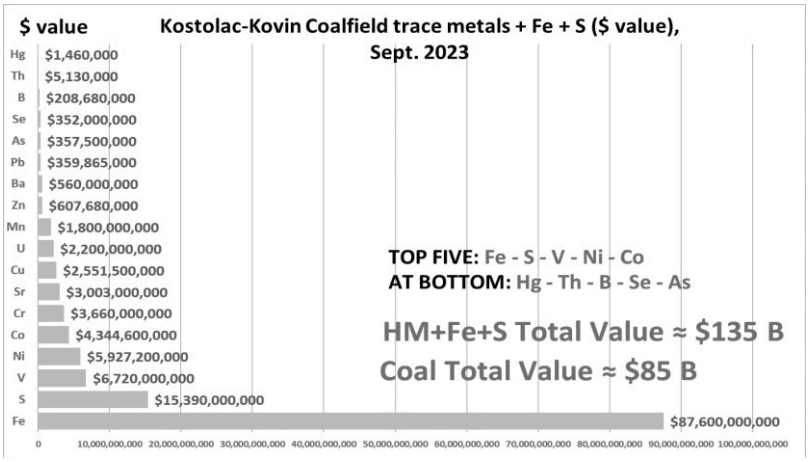

Figure 10, $ value of heavy metals, including S and Fe, from Kostolac-Kovin lignitefield, sept. 2023.

As can be seen, the value of all metals, including Fe and S, is 135 B$; and the value of lignite is only $85B. Although in terms of mass, it has only about 5% of relative representation, in terms of finances, it has 160%. The difference is drastic.

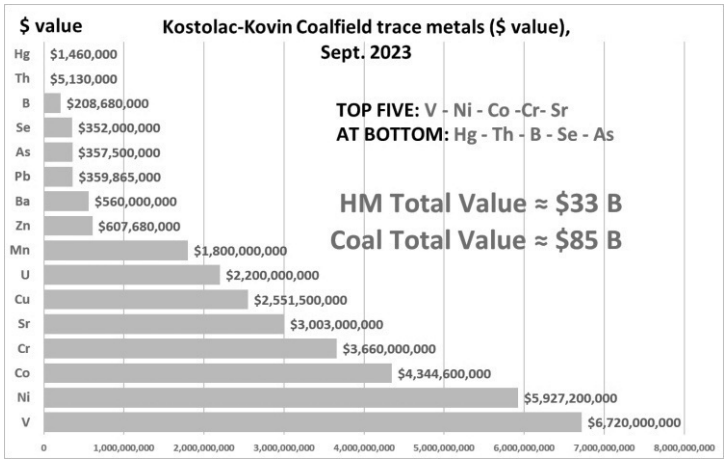

Figure 11, $ value of heavy metals, without S and Fe, from Kostolac-Kovin lignitefield, sept. 2023.

As can be seen, the value of all metals, without Fe and S, is 33 B$; and the value of lignite is only $85B. Although in terms of mass, it has only about 5% of relative representation, in terms of finances, it has 39%.

KOLUBARA LIGNITE AREA

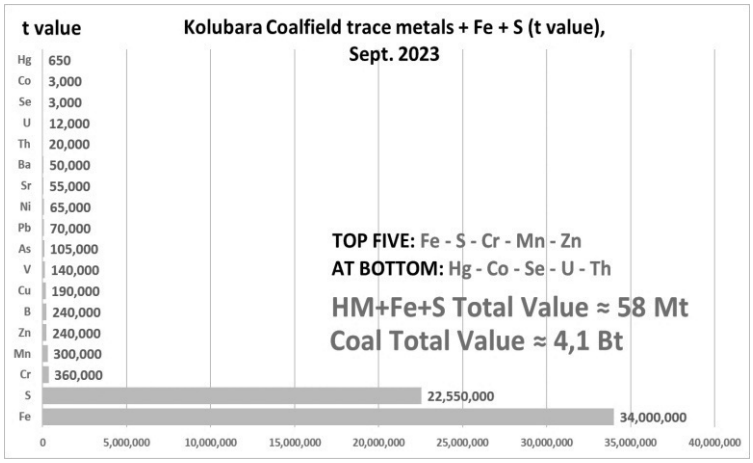

Figure 12, Mass value (t) of heavy metals from Kolubara lignitefield, sept. 2023.

It can be observed that the relative weight share of the mentioned heavy metals is about 1.4% in relation to the total mass of wet lignite. It amounts to about 2.8% of the dry lignite mass.

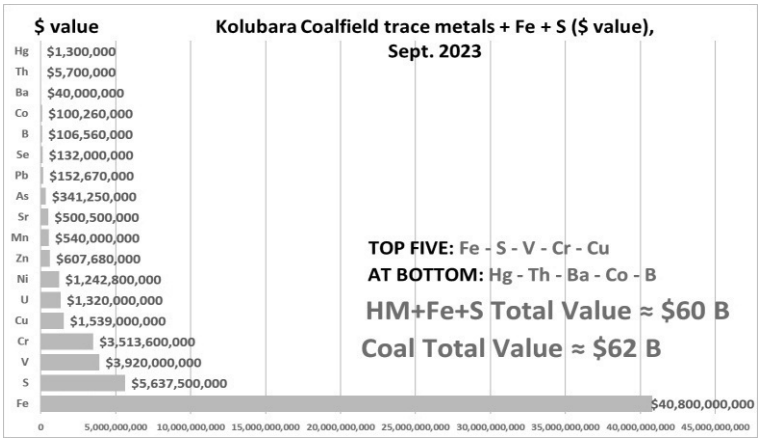

Figure 13, $ value of heavy metals, including S and Fe, from Kolubara lignitefield, sept. 2023.

As can be seen, the value of all metals, including Fe and S, is 60 B$; and the value of lignite is $62B. Although in terms of mass, it has only about 2.8% of relative representation, in terms of finances, it has 97%. Both types of useful minerals have approximately the same financial value.

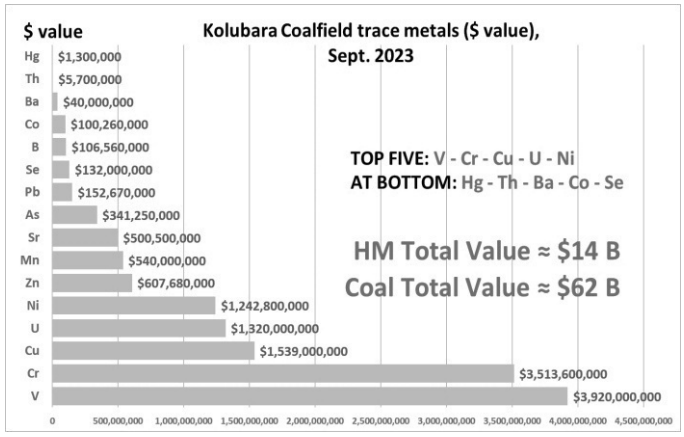

Figure 14, $ value of heavy metals, without S and Fe, from Kolubara lignitefield, sept. 2023.

As can be seen, the value of all metals, without Fe and S, is 14 B$; and the value of lignite is $62B. Although in terms of mass, it has only about 2,8% of relative representation, in terms of finances, it has 23%.

CONCLUSION

The lignite's of the Kostolac-Kovin and Kolubara Lignite Basins generally has low concentrations of heavy metals, compared to selected Serbian, European and Worldwide

lignite's and industrial top soils. In this work, special attention is paid to the content of Zn, Cu, Pb, Co and Cr as pollutants in top soil. Based on this, it can be concluded that the concentrations of the mentioned HM are significantly higher in the top soils of industrial zones of many areas in Serbia, Region, Europe and World which are significantly far from those deposits.

So, we conclude - the lignite from the both deposits itself does not extremely pollute the surrounding soil that is nearby the deposit. The contents of heavy metals in the top soil of the mentioned areas in Serbia, Region, Europe and World are mainly a consequence of the geological composition and geochemical background of that region, as well as their own anthropogenic/industrial influence. Perhaps, in the upcoming days and years, this topic will become the subject of multidisciplinary professional and scientific discussions.

But from another point of view, these same toxic metals can also have economic value. World governments are in a feverish race for strategic metals, which are now no longer toxic, becoming completely acceptable and no one is disgusted by the mention of their name. The individual and total $ value of the listed metals looks fascinating, reaching values expressed in the billions of dollars, surpassing the value of lignite. In this paper, unfortunately, there are no data on lanthanoids, rare earths and rare metals, because the lignite's of Serbia have never been analyzed in the laboratory for their presence.

Note This paper has a strong emphasis on theoretical considerations.*

LITERATURE

[1] Boushka V., Pesheck J, Quality parameters of lignite of the North Bohemian Basin in Czech Republic in comparison with the world average lignite - IJCG, 40, 1999, 2011-235

[2] Brkušanin I., Jovanović G., Izveštaj o ispitivanju zemljišta RB Kolubara, Zaštita na radu i zaštita životne sredine Beograd, Laboratorija za zaštitu na radu i životne sredine, 2016

[3] Čakmak D., Perović V., Saljnikov E., Stanje nepoljoprivrednog zemljišta industrijskih zona većih gradova u republici Srbiji sa aspekta biološkog i hemijskog kvaliteta, Institut za zemljište Beograd, 2016

[4] Ewen C., Anagnostopoulos A.M., Ward N.I., Monitoring of heavy metal levels in roadside dusts of Thessaloniki, Greece in relation to motor vehicle traffic density and flow, Environmental Monitoring and Assessment, 157 (1-4), 2009, 483-498.

[5] Ivanković N., Kašanin Grubin M., Brsecki I., Vukelić N., Possible sources of heavy metals in urban soil: example from Belgrade, Serbia - journal of environmental protection and ecology 11, No 2, 2010, 455-464

[6] Kachova V.G., Atanassova I.D., Heavy metal pools in urban soils from city parks of Sofia, Bulgaria - Agricultural science and technology, Vol. 9, No 2, 2017, doi: 10.15547/ast.2017.02.026

[7] Kuzmanoski M., Todorović M, Aničić Urošević M, Rajšić S., Heavy metal content in urban parks of Belgrade, Hemijska industrija 68 (5), 2014, 643-651

[8] Lacatusu R., Rovena Lacatusu A., Lungu M., Breaban I., Macro and microelements

abundance in some urban soils from Romania - Carpth. J. of Earth and Environmental Sciences, 2008, Vol. 3, No. 1, 2008, 75 - 83

[9] Mihailović A., Budinski-Petković Lj., Popov S., Ninkov J., Vasin J., Ralević N.M., Vučinić Vasić M., Spatial distribution of metals in urban soil of Novi Sad, Serbia: GIS based approach - Journal of Geochemical Exploration, 150, 2015, 104-114

[10] Mihajlov M., Barandovski L., Šajn R., Stafilov T., Spatial distribution of heavy metals in soils in the Republic of Macedonia - Geologica Macedonica, Vol. 30, No. 1, 2016, 41–54

[11] Nikolić Đ., Milošević N., Živković Ž., Mihajlović I., Kovačević R., Petrović N., Multi-criteria analysis of soil pollution by heavy metals in the vicinity of the Copper Smelting Plant in Bor (Serbia) - J. Serb. Chem. Soc. 76 (4), 2011, 625–641 UDC 69.04+669.3:504.53.054+669.4/.5(497.11) JSCS–4146

[12] Pavlov J., Bekrić D., Knežević G., Izveštaj o analizi zemljišta Obrenovac 2018, Institut za zaštitu na radu a.d., Laboratorija za ispitivanje, Novi Sad, 2018

[13] Pavlović P., Sawidis T., Breuste J., Kostić O., Čakmak O., Đorđević D., Pavlović D., Pavlović M., Perović V., Mitrović M., Fractionation of potentially toxic elements (PTEs) in urban soils from Salzburg, Thessaloniki and Belgrade: An insight into source identification and human health risk assessment - International Journal of Environmental Research and Public Health 18, 6014, 2021

[14] Sezgin N., Ozcan K., Demir G., Nemlioglu S., Bayat C., Determination of heavy metal concentrations in street dusts Istanbul E-5 highway, Environment International 29, 2003, 979 – 985

[15] Stefanović P., Radovanović P., Perković B., i dr., Laboratorijske analize uglja reprezentativnih uzoraka uglja Kolubarskog basena, Izveštaj NIV-ITE 369, Institut za nuklearne nauke Vinča, Beograd, 2008

[16] Steingarber L., Ludolphy C., Metz J., Germershausen L., Kierdorf H., Keirdorf U., Heavy metal concentrations in floodplain soils of the Innerste River and in leaves of wild blackberries Rubus fruticosus L. agg.) growing within and outside the floodplain: the legacy of historical mining activities in the Harz Mountains (Germany), Environmental Science and Pollution Research 29, 2022, 22469-22482

[17] Stribescu. R.M., Radulescu C. at all, Spatial distribution of heavy metals in urban soils - Romanian Reports in Physics 71, 705, 2019

[18] Veliu A., Determination of Heavy Metals in Soil in the Industrial Area, Ferronickel Kosovo, J. Int. Environmental Application & Science, Vol. 11(4), 2016, 391-395

[19] Vučković B., Milinković I., Horizontal and vertical distribution of heavy metals (Cu, Pb, Zn) in lignites of Kostolac-Kovin lignite basin, eastern Serbia - XIV Simpoziijum sa međunarodnim učešćem Rudarstvo 2023, Zlatibor, Serbia, 2023, 124-133, ISBN 978-86-80420-27-1, COBISS.SR-ID116330505

[20] Vučković B., Dimitrijević B., Heavy metals in lignite and soil of Kostolac-Kovin lignite basin, eastern Serbia - comparative analysis with selected examples – 9th International Conference MEP 23, Soko Banja, Serbia, 2023

[21] Životić D., Cvetković O., Vulić P., Gržetić I., Simić V., Ilijević K., Dojčinović B., Erić S., Radić B., Stojadinović S., Trifunović S., Distribution of major and trace elements in the Kovin lignite (Serbia), Geologia Croatica, 72/1, 2019, 51–79