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

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ABSTRACT

The Kostolac-Kovin coal basin with an area of 320 km², with 5 separate layers of coal and with a total of about 5.7B tons of geological resources and reserves represents an exceptional potential for coal production in Serbia. Also, the Kolubara coal basin with an exploitable area of about 200 km², with 3 separate coal layers and with a total of about 4.1B tons of geological resources and lignite reserves represents a proven potential for coal production in Serbia. In total, we own nearly 10B tons of geological resources and lignite reserves in both coal mining areas.

The coal 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 coal seams in both coal 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 coal 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, strategic metals, economic value*

1. GENERAL INFORMATIONS

COAL BASIN KOSTOLAC-KOVIN (EAST SERBIA)

Generally, the coal 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 coal basin, red circles - position of the lignite basins; left- Kolubara Coal Mines, right – Kostolac Coal 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 coal 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 coal resources for all 5 coal seams yielded about 5,7B t of coal.

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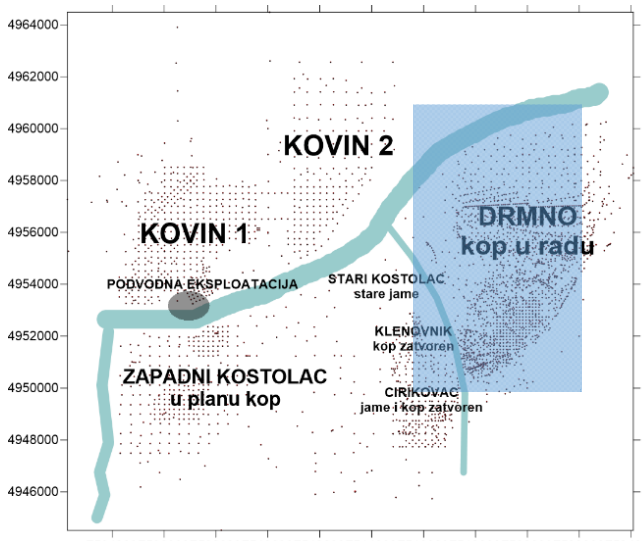

Figure 2. General overview of exploration drill holes (black dots) for the period 1941-2023. year in the Kostolac-Kovin coal-bearing basin, blue thick line – river Danube, blue thin line left – river Velika Morava, blue thin line center – river Mlava, gray circle - underwater mining of Kovin lignite;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

COAL BASIN KOLUBARA (WEST SERBIA)

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

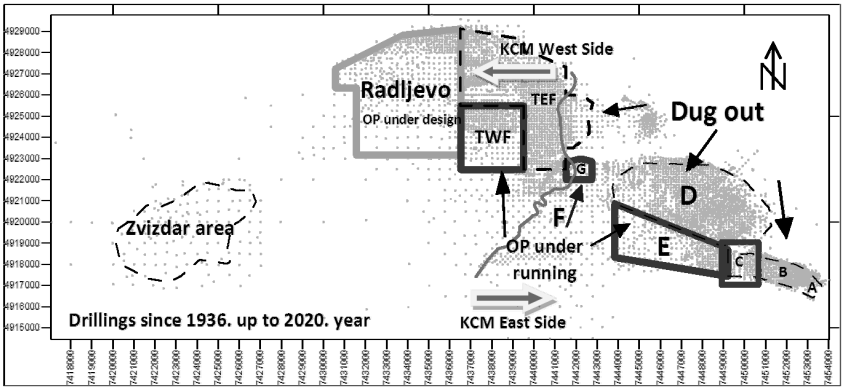

Figure 3. KCM[2] operational area, drill-holes since 1936. year; total >7,500 holes, e.g. 605,000 m of core drilling; curved line – river Kolubara divide area on East and West side

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. Coal 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.

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

In Kostolac-Kovin coal 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 have also been determined. Apart from coal, 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 [124-131,145].

[2] KCM - Kolubara Coal Mines

In Kolubara Coal Mines there are ecology explorations in a smaller scale. Most explored area relate with open pits surrounding top soil and some lignite layers [114, 144].

HEAVY METALS IN COAL – 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.

However, numerous measured data from surface coal 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 [1-145]. Considering that this issue is extremely extensive, we only give a few characteristic examples (figures 4-8).

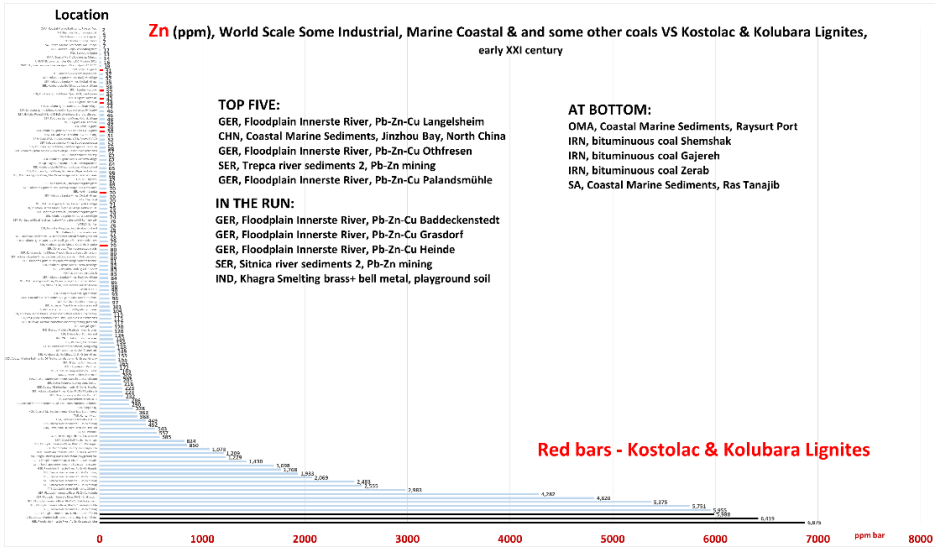

Figure 4. Zinc (Zn) concentrations in top soil of some industrial zones worldwide VS. Kostolac - Kovin and Kolubara lignites

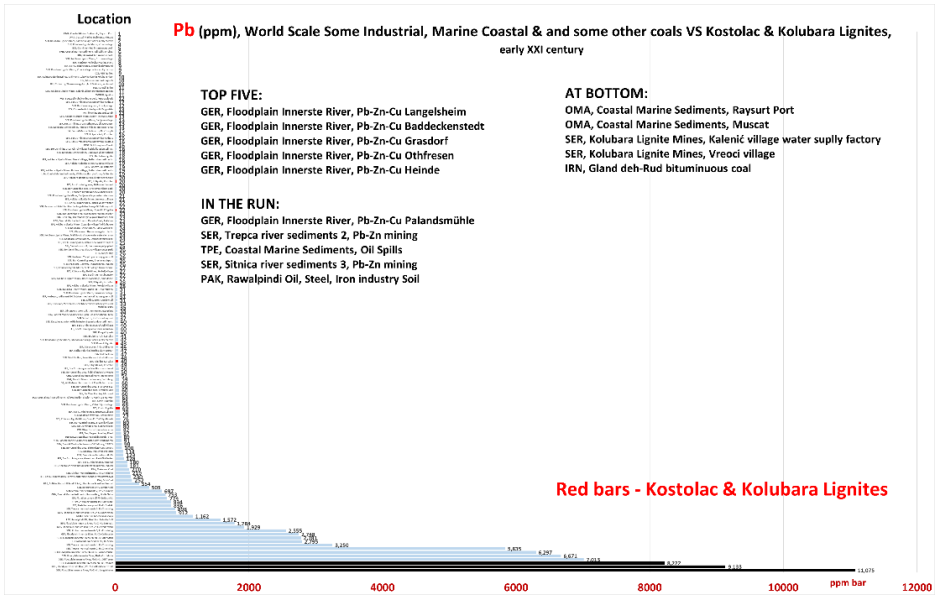

Figure 5. Lead (Pb) concentrations in top soil of some industrial zones worldwide VS. Kostolac - Kovin and Kolubara lignites

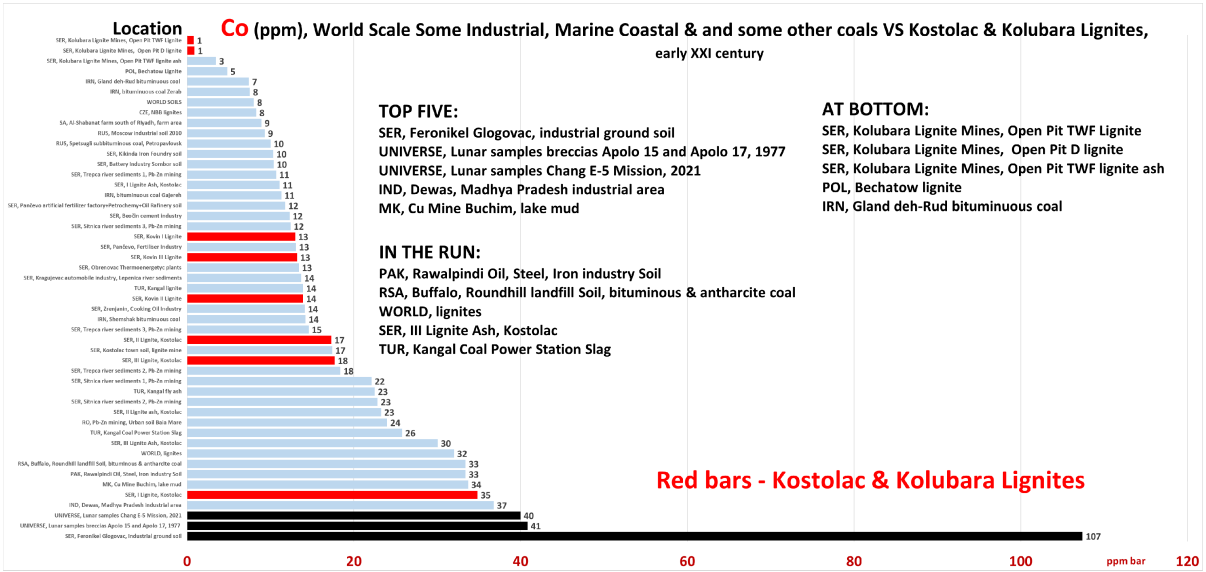

Figure 6. Copper (Cu) concentrations in top soil of some industrial zones worldwide VS. Kostolac - Kovin and Kolubara lignites

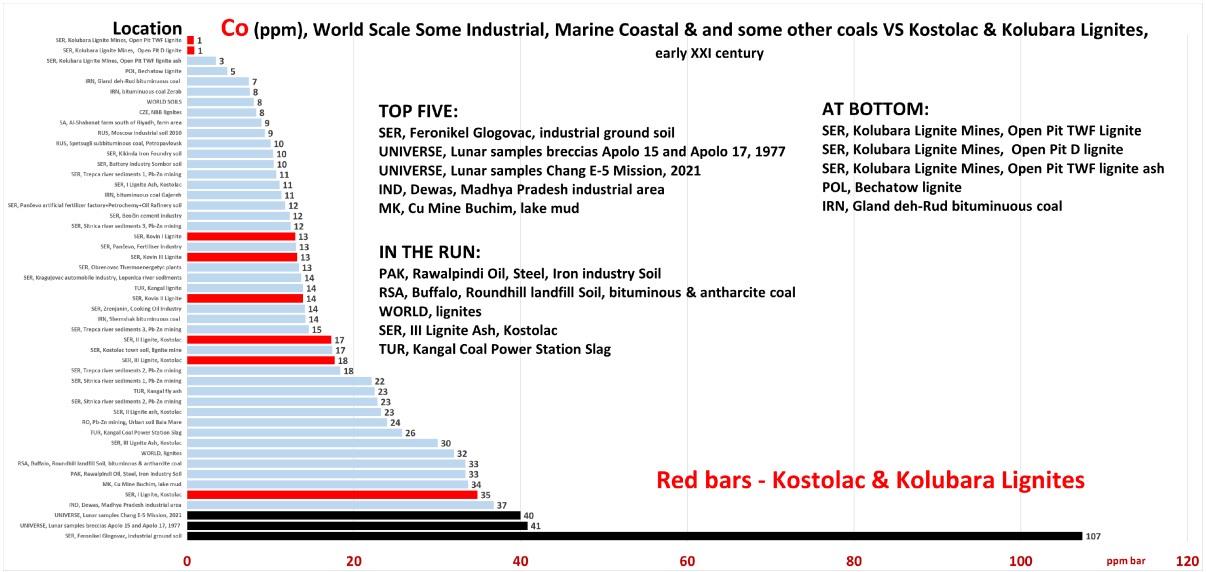

Figure 7. Cobalt (Co) concentrations in top soil of some industrial zones worldwide VS. Kostolac - Kovin and Kolubara lignites

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 [60, 136]. Even, in several extreme examples, the contents are even 300 times higher [115, 122].

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?

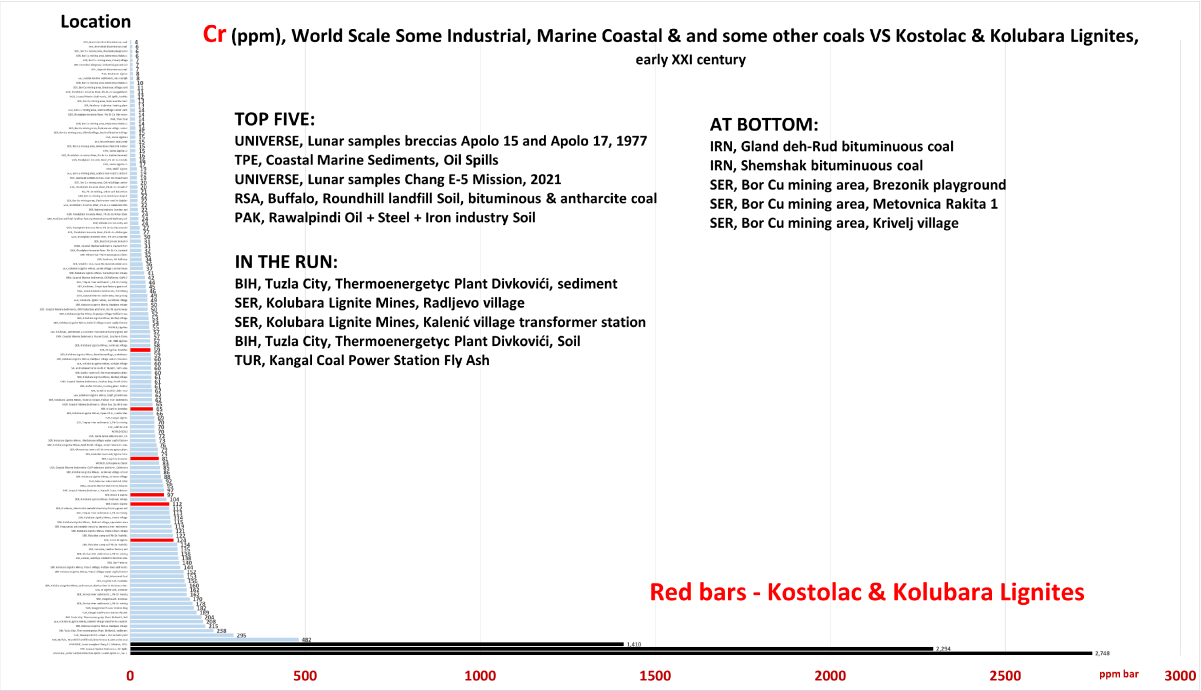

Figure 8. Chromium (Cr) concentrations in top soil of some industrial zones worldwide VS. Kostolac - Kovin and Kolubara lignites

3. AND NOW WHAT

Recently, numerous world governments have declared an insatiable need for "strategic minerals". In this, the governments of the USA, EU, Japan, etc., will 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 coal have any economic value.

4. 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 game get them as a 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 concentrations in the coal of both basins for consideration. Also, we deal with total quantities of coal 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 COAL AREA

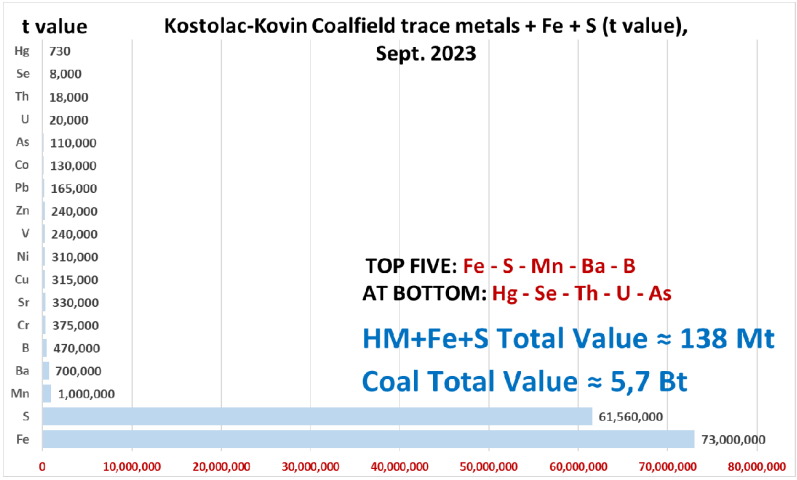

Figure 9. Mass value (t) of heavy metals from Kostolac-Kovin coalfield, sept. 2023.

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 coal. It amounts to about 5% of the dry coal mass.

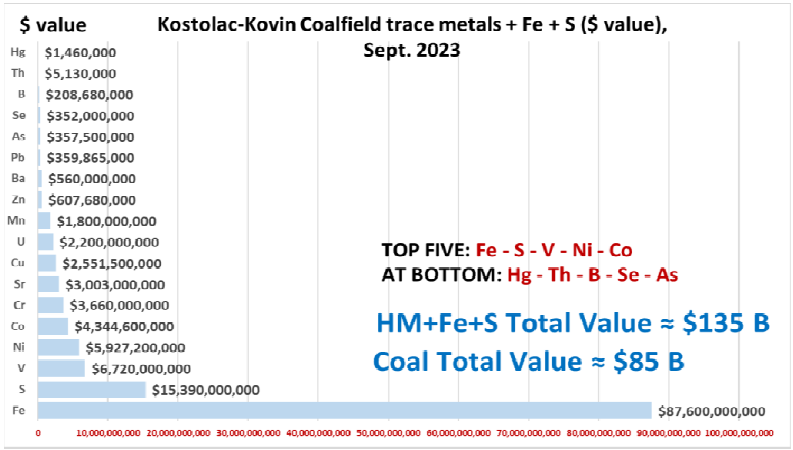

Figure 10. $ value of heavy metals, including S and Fe, from Kostolac-Kovin coalfield, sept. 2023.

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.

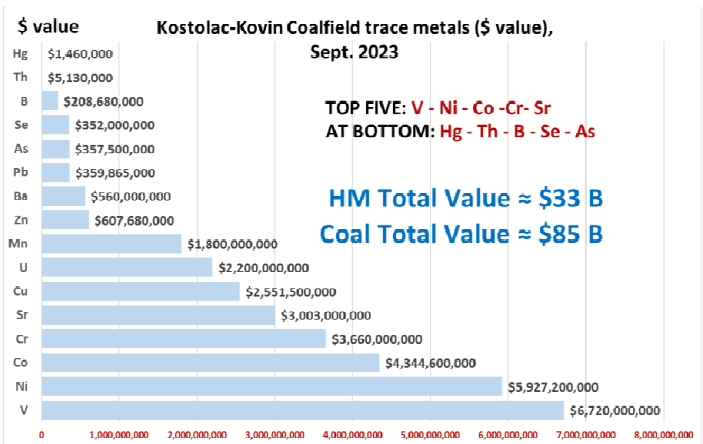

Figure 11. $ value of heavy metals, without S and Fe, from Kostolac-Kovin coalfield, sept. 2023.

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 COAL AREA

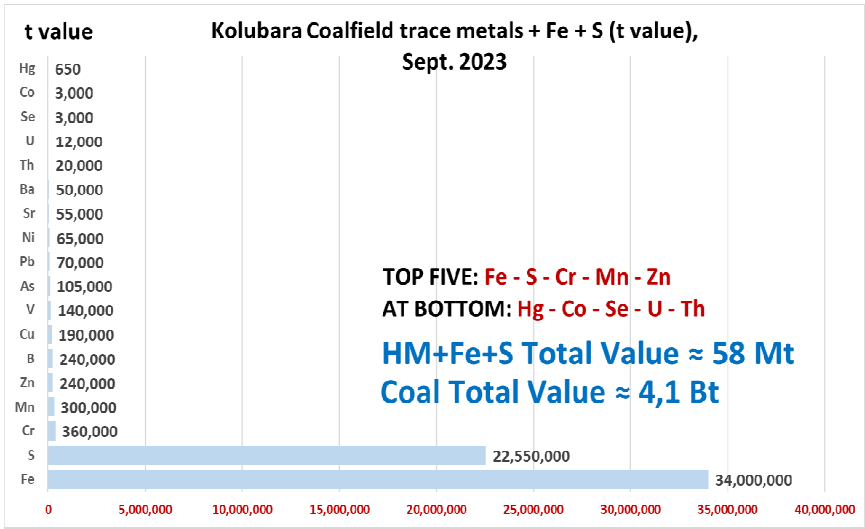

Figure 12. Mass value (t) of heavy metals from Kolubara coalfield, sept. 2023.

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 coal. It amounts to about 2.8% of the dry coal mass.

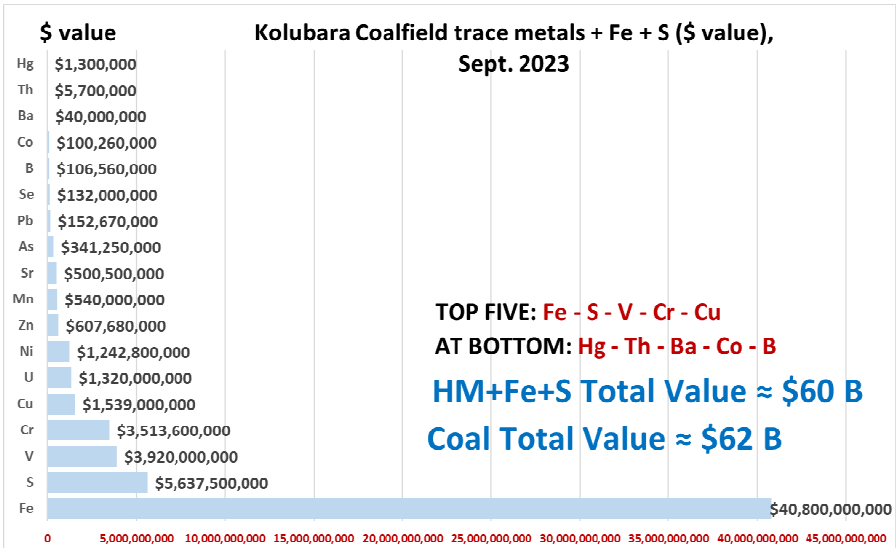

Figure 13. $ value of heavy metals, including S and Fe, from Kolubara coalfield, sept. 2023.

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.

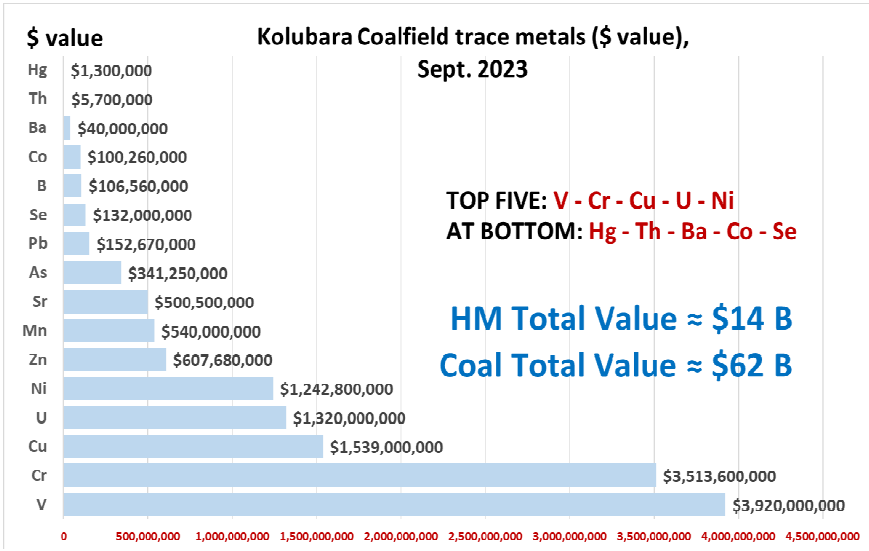

Figure 14. $ value of heavy metals, without S and Fe, from Kolubara coalfield, sept. 2023.

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 lignites of the Kostolac-Kovin and Kolubara Coal Basins generally has low concentrations of heavy metals, compared to selected Serbian, European and Worldwide coals 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 coal 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 anthropogenic/industrial influence. Perhaps, in the coming days and years, this topic will become the subject of multidisciplinary professional and scientific discussions.

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

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