International Journal of Innovation, Creativity and Change. www.ijicc.net
Volume 12, Issue 3, 2020

Water Pollution, Income Loss and Health Impact as Externalities from Illegal Gold Mining: A Case Study from Two Districts in Jambi Province, Indonesia

Muhammad Ridwansyah[a*], Sopian Hidayat[b], Heriberta[c], Nurul Anwar[d],
[a]Faculty of Economics and Business, University of Jambi, Kampus Pinang Masak Jl. Raya Jambi-Ma. Bulian KM. 15, Mendalo Darat, Jambi, Indonesia, [b]Conservation Strategy Fund Indonesia, Graha Simatupang, Tower 2, Unit C, Jl. TB. Simatupang, Kav. 38, Jakarta 12540, Indonesia, [c,d]Faculty of Economics and Business, University of Jenderal Soedirman, Jl. Profesor DR. HR Boenyamin No.708, Dukuhbandong, Grendeng, Kec. Purwokerto Utara, Kabupaten Banyumas, Jawa Tengah 53122, Indonesia

This study examined the water pollution, incomes loss, and health impact as externalities caused by illegal gold mining (IGM) activities in two districts (Merangin and Batanghari) in Jambi Province, Indonesia. This study conducted face to face interviews from June ?? to July 2018 of hundred respondents from two districts on their perspectives of IGM. The result found that two villages (Baru and Tiga Alur) were severely affected by the IGM activities. Most of the excavated lands were ex-rice fields owned by the residents who thought the IGM more profitable than farming. This study revealed that the agricultural production cost is more than double since the IGM existed in the area so that less household income received. It also found people in the districts are suffering from skin infections, acute respiratory infection (ISPA), smallpox, asthma, and cough. The sample analysis demonstrated water from Batanghari River, and Merangin River contained a low level of mercury, but it may intensify if the IGM is persisted in the area and cause a more significant impact on health. It also detected the existence of E. Coli and coliform in Batanghari River. The People's Mining Area (WPR) is expected to provide a solution to various impacts that occurred.

Keywords: *Water pollution, income loss, health impact, illegal gold mining, Indonesia*

Introduction

Gold mining is valuable to develop a country's economy if appropriately managed. However, there is always a trade-off between economic growth, environmental sustainability and health condition, as pollution of the environment becomes normal due to the excessive exploitation of natural resources (Awan, 2013). The concerns not only on health but also water pollution, noise, conflicts over land use, loss in the air quality and greenhouse emission through land degradation and deforestation. Studies have shown that gold extraction (large and small scale) can significantly degrade natural environments, human health and livelihoods (Alves et al., 2017; Hilson, 2002). For decades, large volumes of untreated wastes have been discharged into surrounding air, soils and water and since thirty years ago, only selected mines have experienced noticeable reductions in pollution and achieved marked improvements in environmental management (Hilson, 2000). Common environmental impacts from mining activity are deforestation, air pollution, erosion, land degradation, and acid mine drainage (Hilson, 2002; Alves et al., 2017). The most severe environmental impact is mercury contamination (Hilson, 2002) which miners routinely discharge toxic chemicals and their harmful compounds into water bodies—thus exposing workers and residents to a range of health risks including lower respiratory tract infections, cardiovascular diseases, skin infection and other health problems (Akpalu and Normanyo, 2017; Franchini and Mannucci, 2007, 2009; Obiri et al., 2010). Environmental pollution caused by mercury is not only harmful to human health but also animals, plants and the continuity of life in the surrounding environment (Widowati et al., 2008). Though at low concentrations, the effect of mercury is direct and can accumulate in the food chain (Lestarisa, 2010).

Indonesia is known as one of the leading gold producers in the world, and total gold reserves are estimated at 3,000 tons (Utomo et al., 2014). Indonesia's small-scale gold mining sector comprised of some 77,000 operations that generate earning of US$58 million each year (Hilson, 2002). Mining activities against the rules have resulted in environmental damage, waste of mineral resources and mining accidents. Illegal mining causes not only the potential for state revenues to decrease, but also the government has to spend substantial funds on improving the environment. Therefore, through the Presidential Instruction of the Republic of Indonesia No. 3 of 2000, instructed to the Minister, Attorney General, National Police Chief and Governor and Regents/Mayors to make efforts to overcome problems, control and terminate all forms of illegal mining activities functionally and comprehensively according to their duties and authority (Gerasimova et al., 2019: Nuriyev et al., 2018).

Illegal gold mining is found in various regions in Indonesia, among others in West Java (Pongkor, Bogor), North Sulawesi (Kulo), West Kalimantan (Landak), Central Kalimantan (Gunung Mas), and Jambi (Sarolangun, Bungo, Batanghari and Merangin). This study assessed the externalities impact of illegal gold mining on the environment, livelihood, and health of the

surrounding community in the districts of Merangin and Batanghari, Jambi Province (Soodmand Afshar et al., 2018).

Literature Review

Small-scale mining plays a fundamental role in alleviating poverty in the developing world and contributes significantly to national revenues. It plays a pivotal role in relieving poverty in many rural regions of the developing world, primarily because it is viable in remote areas with minimal infrastructure where other industries could not function (Hilson, 2002). Though small-scale mining is inherently environmentally destructive and can cause a number of health and safety complications, it also provides many important socio-economic benefits to millions of people (Hilson, 2002).

Several studies have discussed the impact of illegal gold mining (IGM) in Jambi especially in Sarolangun (Yulianti et al. .2016; Arbi and Aidha 2017; Susanti et al. 2018) and Merangin (Wahyudi and Firdaus, 2018). Yulianti et al. (2016) and Arbi and Aidha (2017) analysed the mercury content in the water. The amalgamation used by the illegal miner caused deterioration in water quality and the existence of mercury concentration (0.0003 mg/i) in the Batang Limun River, Sarolangun (Yulianti et al., 2016). Whereas Arbi and Aidha (2017) found the concentration of mercury in Pelawan River, Sarolangun is 0.007 mg/l, which is far past the quality standard based on Government Regulation No.82 of 2001. Susanti et al. (2018) study found that illegal gold mining (IGM) caused noise pollution, dust, degradation on the quality of Batang Asai River, forest conversion, river siltation, the emergence of large holes, soil abrasion, the disappearance of Meranti plants (Shorea sp.) and Damar (Agathis Damara), also declining population of Semah Fish (Tor sp.). In Merangin, Wahyudi and Firdaus (2018) assessed the impact of IGM on rice farming using sustainability index. They found the IGM reduced rice production due to the growing number of plan pest, land degradation and air pollution.

Besides, several studies have been carried out to examine the effects of mercury due to mining activities in Indonesia (Sudarmaji et al., 2004; Rudolf, 2004; Nopriadi et al., 2006; Lestarisa, 2010). Sudarmaji et al. (2004) found Kenjeran Turkish citizens in Surabaya who consumed fish from the contaminated river experienced kidney pain, dizziness, tumours, bleeding gums, and sight problems. Nopriadi et al. (2006) revealed the use of mercury in IGM in the Kuansing District, Sumatra caused mood changes, sleep disturbances, depression, memory loss, irritability, reduced hearing and eyesight, tingling around the mouth, fingers and toes, tremor (such as impaired coordination, impaired balance, ataxia), stomatitis (increased salivation, pneumonitis followed by fever, dyspnea), chronic gingivitis, weight loss, continuous headache, anemia and frequent urination. Lestarisa (2010) sampled the gold miners in Kapuas River

Sintang district, West Kalimantan and found the effect of mercury exposure among them, including quickly tired, headache, shaking or shivering and stiff joints.

Method

This study was conducted in two districts, Merangin and Batanghari (Figure 1). The sites were purposively selected based on the consideration as the most intense area of having IGM in Jambi Province. These districts have seen a rapid expansion of IGM activities within the past five years. Five villages in three sub-districts were sampled; Desa Baru, Tiga Alur, Limbur Merangin, Mata Gual and Koto Buayo. These sites represent the upper area, middle area and lower area of IGM in both districts.

Table 1: Study sites

Area	Villages	Sub-districts	Districts
Upper area	Desa Baru	Pangkalan Jambu	Merangin
	Tiga Alur	Pangkalan Jambu	Merangin
Middle area	Limbur Merangin	Pamenang Barat	Merangin
Lower area	Mata Gual	Batin XXIV	Batanghari
	Koto Buayo	Batin XXIV	Batanghari

This study gathered data through i) focus group discussion (FGD) with farmers, village community leaders, and villagers; and ii) interviews with local people to get information on the impact of IGM. For interviews, semi-structured questionnaires were administered to 100 respondents, and respondents were randomly selected within five villages. About 20 – 30 households were sampled proportionally for each village (Table 2). The survey was conducted from June to July 2018. The information collected from the questionnaires, including demographic and socio-economic data, and information on the impact of IGM on three aspects: livelihood, environment and health condition.

Table 2: Sample of respondents

Area	Villages	Number of Households
Merangin districts (Upper area)	Desa Baru	20
	Tiga Alur	20
Merangin districts (Middle Area)	Limbur Merangin	30
Batanghari districts (Lower area)	Mata Gual	15
	Koto Boyo	15

This study used total costs of production (TC) and total income loss approach before and after the existing of IGM to measure the impact of IGM. The entire production costs derived from both variable costs (VC) and fixed costs (FC) accumulated as total costs in agricultural

production (equation 1). Variable costs consisted of purchased seed, fertilisers, labour, operational and maintenance cost for agricultural machinery. Fixed costs comprised of depreciation cost, land rent and opportunity costs of capital owned (FAO, 2015).

For the total household income, it referred to an accumulation of individual income within one household (equation 3). Total income loss generated from the difference between total household income loss before and after the introduction of IGM activities (equation 4).

$$TC = FC + VC \quad \ldots\ldots (1)$$

$$\Delta TC = TC_{\text{after IGM}} - TC_{\text{before IGM}} \quad \ldots\ldots (2)$$

$$Y = \sum(y_i) \quad i= 1, 2, 3,\ldots n \quad \ldots\ldots (3)$$

$$\Delta Y = Y_{\text{after IGM}} - Y_{\text{before IGM}} \quad \ldots\ldots (4)$$

From the initial survey, several sampling points were taken along Batanghari River at Desa Bulu Kasap, Desa Pematang Gadung, Desa Rantau Kapas Mudo and Desa Kubu Kandang as well as Merangin River (upstream, middle stream and downstream) to test mercury concentration and other parameters. In this study, the quality standard used is in accordance with the Government Regulation of the Republic of Indonesia Number 82 of 2001 concerning Management of Water Quality and Water Pollution Control. It means, for the mercury, it concentrations should not exceed the quality standard, which is 0.002 mg / L.

Results and Discussion

Characteristics of Respondents

Table 3 shows the characteristics of respondents where the number of males is greater than female. However, the role of the female in the IGM activities is very crucial for the "panning" process, and it started in the morning until late afternoon. Most of the respondents have lower education level (elementary school); married, and classified as young with age ranging between 26 and 35 years old. Based on these characteristics, their decision to involve in IGM is a short time choice without totally considered the health impact in the long term.

Table 3: Characteristics of respondents

Variable		**Percentage**
Gender	Male	57
	Female	43
Marital Status	Single	8
	Married	92
Age	26-35	34
	36-45	32
	46-55	19
	56-65	13
	>65	2
Education level	No formal education	4
	Primary school	43
	Middle school	21
	High school	23
	University	9

Perception of Respondents on the Impact of IGM

This study classified the impact of IGM on three aspects ─ livelihood, health and environment. From the survey, the study found most of the respondents expressed both livelihood and environmental conditions were affected by IGM (47%). About 32% answered that only environmental condition was affected, and the rest of them felt disturbing on their livelihood and health (19%). The rice farmers, livestock farmers and fishers who relied on the river for their income are the most affected group due to the polluted river.

The economy of Merangin and Batanghari districts relied on the agricultural sector. This study highlighted that most peoples perceived the IGM had negatively affected their livelihood, especially rice farmers and rubber planters. When gold mining system was introduced, the villagers were competing to dig the soil suspected of having gold, and most of the land extracted is the rice fields owned by the residents. Rubber planters abandoned their plants and joining the mining activities to gain side income. Since the IGM came to the place, they experienced worse water quality.

Worse water quality leads to decreasing health condition among the community living along the Batanghari river bank. They use water for drinking, showering, watering the crops, and cleaning the clothes. Some symptoms had been identified among the respondents such as skin infection, cough and flu, and breathless. In this case, the symptoms of skin infections were itching, pain, and tenderness. The health impact will be more severe if there is no prevention way to solve this problem.

Impact on the Environment and Agricultural Land

This study found six environmental impacts caused by IGM: 1) worse water quality; 2) flood; 3) landslide; 4) river silting; 5) decreasing fish population; and 6) air pollution. However, due to budget constraint, only water quality is further evaluated in this paper.

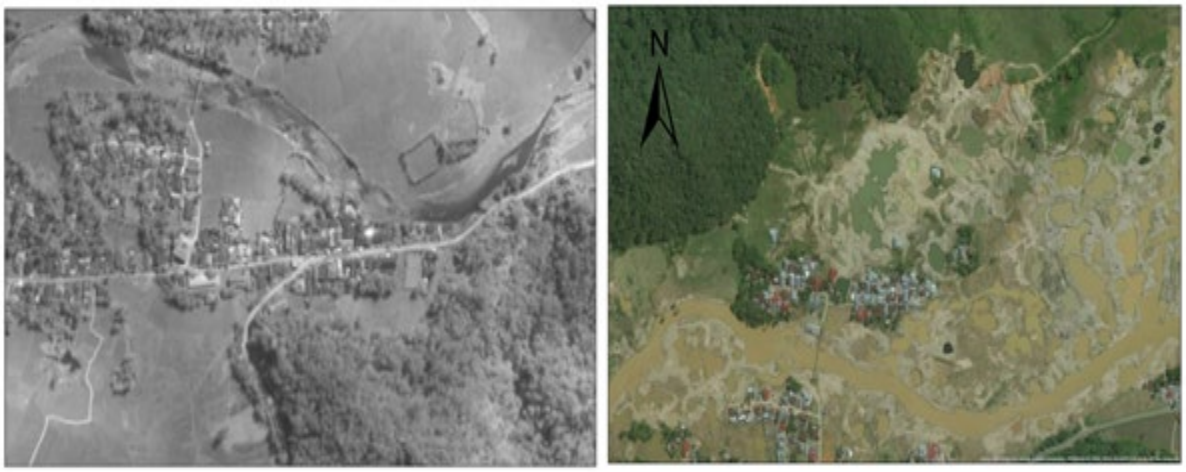
IGM in Merangin District is getting rampant by the public since 2015. This IGM has damaged the rice fields and the environment, waste of mineral resources, and mining accidents that claimed hundreds of lives. For example in Desa Baru, this village once had extensive rice fields and was known as the Merangin's food barn, now after this IGM came, the paddy field was destroyed, and rice production was dropped (Wahyudi and Firdaus, 2018). But after several years, the community started to realise the gold was depleted in their land. So they piled up to re-plant paddy. This was somehow not helping the paddy production and made 825 ha farmlands infertile.

Moreover, IGM in Merangin caused water pollution in Manau River and Mesumai River, it flows to downstream Batanghari River, and also tributaries to the residential area, and irrigation dams of rice fields. This caused Batanghari River is no longer appropriate for human consumption due to the muddy and suspected contaminated waste with mercury (Hg) which directly discharged by illegal gold miners into a river or the irrigation dam. Even until now there are many people who are panning on the river banks to search for gold, especially in Desa Baru. Residents also acknowledged the river in Limbur Merangin is no longer suitable for bathing and washing because the water is muddy due to the mining activities; thus, residents built wells near the house for daily water needs. According to residents, this condition is due to the existence of gold mining activities carried out in Manau River and Pangkalan Jambu sub-district. Residents are concerned, and they plan to take legal action against this water pollution problem. While for residents of Koto Boyo, they claimed their muddy river is caused by mining machine called "dompeng", operated in Mata Gual (Koto Boyo is adjacent to Mata Gual). In fact, most peoples in both villages still use the water for bathing and washing.

The land degradation caused by IGM can be seen clearly from the Landsat Satellite image, especially in Desa Baru and Tiga Alur (Figure 1 and 2). Both sites are the centre of IGM in Merangin District.

Figure 1. Desa Baru before and after the IGM

Figure 2. Tiga Alur before and after the IGM



Mercury Concentration and Water Contamination

From the laboratory test by the Environmental Agency of Jambi Province (the authority that measured water quality in the Province), Merangin and Batanghari Rivers contained low mercury level (Table 4). However, it may intensify if the IGM is persisted in the area and cause a more significant impact on health. The analysis also shows the presence of E.coli and coliform in the samples taken from the Batanghari River (Table 5). E. coli is the bacteria that lead to gastroenteritis, acute diarrhea, and inflammation of the bladder if it enters the human body. Coliform can produce ethionine substances that are carcinogenic and cause toxic to human.

Table 4: Mercury content in Merangin River and Batanghari River (mg/L)

Location	Mercury content
Desa Bulu Kasap, Kab. Batanghari (avg)	2.83E-04
Desa Pematang Gadung, Kab. Batanghari (avg)	2.62E-04
Desa Rantau Kapas Mudo, Kab. Batanghari (avg)	3.97E-04
Desa Kubu Kandang, Kab. Batanghari (avg)	4.63E-04
Bukit Aur (Batang Merangin River)	3.00E-05
Pulau Kemang (Batang Merangin River) Up stream	3.00E-05
Pulau Kemang (Batang Merangin River) Down stream	3.00E-05
Pulau Kemang (Batang Merangin River) Middle stream	3.00E-05
RPD Bangko Tinggi (Batang Merangin River) Up stream	3.00E-05
RPD Bangko Tinggi (Batang Merangin River) Down stream	3.00E-05
RPD Bangko Tinggi (Batang Merangin River) Middle stream	3.00E-05

Source: Department of Environment of Jambi Province, 2018.

Table 5: Existence of E.coli and coliform in Batanghari River (mg/L)

Location	E. coli	Coliform
Desa Bulu Kasap, Kab Batanghari (avg)	1.127	1.763
Desa Pematang Gadung, Kab Batanghari (avg)	1.267	2.157
Desa Rantau Kapas Mudo, Kab Batanghari (avg)	1.405	2.433
Desa Kubu Kandang, Kab Batanghari (avg)	1.507	2.667

Source: Department of Environment of Jambi Province, 2018.

Type of Diseases Suffered by People from IGM Activities

There were several possible diseases suffered by people due to consuming contaminated water from the stream. Statistic Agency of Merangin District had recorded that in the year 2013 and 2018, the top diseases suffered by people in this area were tuberculosis (TBC), skin problem, flu and smallpox. While in Batanghari District, the high diseases suffered by people were such as acute respiratory infection (ISPA), skin problem, and asthma (Central Bureau of Statistics, 2018). There was an increasing number of people getting the disease, and some others were decreasing over the last decade. In Merangin District, for instance, TBC was the most feared disease in this area, and around 185 sufferers had been hospitalised at the beginning of the period (2008), and this was prominently reaching out to 1,628 or approximately 900% at the end of this period (2018). This is a thoughtful problem, and both national and sub-national government should pay attention to these issues.

Table 6: Type of diseases caused by contaminated water from IGM activities

District and Year	**TBC**	**Skin Problem**	**Smallpox**	**Flu**
Merangin 2018	1,628	8,625	324	446
Merangin 2013	238	3,726	669	8,960
Merangin 2008	185	13,656	n/a	8,047
	ISPA	**Skin Problem**	**Asthma**	
Batanghari 2018	5,939	29	5,622	
Batanghari 2013	26,766	210	3,172	
Batanghari 2008	n/a	161	n/a	

Source: Central Bureau of Statistics from several years (2008 – 2018)

Perception of the Impact of IGM

Table 7: People perception on the impact of illegal gold mining (IGM)

The illegal mining impact (%)		**Livelihood impact (%)**		**Environmental impact (%)**		**Health impact (%)**	
Both livelihood and environment	47	Agriculture (rice field and plantation)	89	Worse water quality	79	Caugh and flu	28
Livelihood, environment and health	19	Fishermen	2	Flood	3	Skin infection	70
Livelihood only	1	Livestock	3	Landslide	7	Breathless	2
Environment only	32	Others	6	River silting	2		
Health only	2			Decreasing fish population	2		
				Air pollution	7		
Total	**100**		**100**		**100**		**100**

Source: Households survey, 2018

Impact on Household Income

From the analysis, this study found that people perceived their household income are declining and the production costs of operating agricultural activity tends to be higher in comparison before and after the IGM existed in the area.

Before the IGM blooming, they are able to generate monthly household's income about IDR 5.5 million. However, the household's income started to decrease significantly, and they only received about IDR 4 million per month (reduced by IDR 1.5 million). Looking at the production cost, the respondents noticed that current production is not as much as before the IGM came. People averagely spent about IDR 864,000 per month, but now it was more than double. The production cost became higher; however, the income is getting lower. On average, the cost spent on agricultural production was about IDR 1.8 million per month. Moreover, the IGM had destroyed their farmland and creating a polluted river near the area.

Table 8: Household income and production cost difference before and after IGM (IDR '000)

	Mean	**Obs**	**Std. Dev.**	**Min**	**Max**
Household income before IGM[a]	5,484	100	6,138	300	31,600
Household income after IGM[b]	3,965	100	8,234	120	60,000
Total production cost before IGM[c]	864	100	3,392	900	27,000
Total Production cost after IGM[d]	1,801	100	6,539	900	39,000
Income difference[b-a]		(1,519)			
Production cost difference[d-c]		937			

Source: Households survey, 2018

Conclusion and Recommendation

This paper examined the impact of small-scale IGM on water pollution, income loss and health in Merangin and Batanghari districts. The activity is centred in the District of Pangkalan Jambu and Kecamatan Sungai Manau. It is identified that Desa Baru and Tiga Alur are the most severely affected villages as the mining activity is done by digging the land instead of panning. Most of the excavated soils were rice fields owned by the residents. It not only caused the land infertile but also resulted in water pollution.

The polluted water in the Manau and Mesumai River also flows to downstream Batanghari River and tributaries where the water flows to the residential area and irrigation dams of rice fields. The IGM activities conducted at the upstream of the Batanghari River also impacted peoples living in the downstream that depends on the river for daily needs. Worse water quality leads to decreasing the quality of livelihood and health condition among the community living along Batanghari river bank. Those who use water for drinking, showering, watering the crops, and cleaning the clothes experienced skin infection, cough and flu, and breathless. From the sample analysis, the Batanghari River and Merangin River contained a low level of mercury. The sample also showed the existence of E.coli and coliform in Batanghari River, which may cause toxic to human. This study also revealed that the agricultural production cost is higher since the IGM entered the area.

This study suggests the People's Mining Area (WPR) as a solution to the problem to lessen the impact. The establishment of WPR is anticipated to handle IGM in addition to its legal enforcement. The Indonesian government issued the implementation guidance for The Law of Mineral and Coal under Indonesian Government Regulation No. 22/2010. Referring to the regulation, the authority for giving WPR is under district government. Besides, to improve the sustainability of the small-scale mining industry, Hilson (2002) suggested the government should (1) legalise small-scale mining and implement sector-specific legislation; (2) contribute to community development and increase economic support; and (3) provide training and educational assistance.

Acknowledgement

This work was supported by the grant from Faculty of Economic and Business University of Jambi, Ministry of Science and Technology of Indonesia (SP-DIPA-042.01.2.400950/2018, 05 December 2017, Agreement contract: 1700/UN21.17/LT2018, 23 April 2018).

REFERENCES

Akpalu, W., & Normanyo A. K. (2017). Gold Mining Pollution and the Cost of Private Healthcare: The Case of Ghana. Ecological Economics, 142, 104-112.

Alves, W., Ferreira, P., & Araújo, M. (2017). Mining cooperatives in Brazil. Manufacturing Engineering Society International Conference 2017, MESIC 2017, 28-30 June 2017, Vigo (Pontevedra), Spain, Procedia Manufacturing, 13, 1026-1033.

Awan, A. G. (2013). Relationship between environment and sustainable economic development: A theoretical approach to environmental problems. International Journal of Asian Social Science, 3(3), 741-761.

Central Bureau of Statistics. (2018). Kabupaten Batang Hari Dalam Angka 2018. BPS-Statistic of Batang Hari Regency, Indonesia: CV. Suber Sentosa Multimedia.

Central Bureau of Statistics. (2018). Kabupaten Merangin Dalam Angka 2018. BPS-Statistic of Merangin Regency, Indonesia: Percetakan Sinar Jaya.

Department of Environment of Jambi Province, (2018). unpublished data.

FAO. (2015). Handbook on Agricultural Cost of Production Statistics. Food and Agriculture Organization of the United Nations.

Franchini, M., & Mannucci, P. (2009). Particulate Air Pollution and Cardiovascular Risk: Short-term and Long-term Effects. Seminars in Thrombosis and Hemostasis, 35(07), 665–670.

Franchini, M., & Mannucci, P. M. (2007). Short-term effects of air pollution on cardiovascular diseases: outcomes and mechanisms. J. Thromb. Haemost, 5(11), 2169–2174.

Gerasimova, L. N., Polenova, S. N., Mislavskaya, N. A., & Sotnikova, L. V. (2019). Methods of functional and process accounting of environmental costs. Edición Especial, 35(23).

Hilson, G. (2000). Barriers to implementing cleaner technologies and cleaner production (CP) practices in the mining industry: a case study of the Americas. Miner. Eng, 13(7), 699–717.

Hilson, G. (2002). Small-scale mining and its socio-economic impact in developing countries. Natural Resources Forum, 26(1), 3–13.

Lestarisa, T. (2010). The Factor Associated with Mercury (Hg) Poisoning on Illegal Gold Miners in The Sub-District Kurun, Gunung Mas of Central Kalimantan. Article, PPS–Diponegoro University, Semarang.

Nuriyev, M., Sovetkanova, D., & Seysenbayeva, Z. (2018). Achievements and new challenges in the area of education of independent Kazakhstan. *Opción*, *34*(85-2), 337-352.

Obiri, S., Dodoo, D. K., Essumang, D. K., & Armah, F. A. (2010). Cancer and Non-Cancer Risk Assessment from Exposure to Arsenic, Copper, and Cadmium in Borehole, Tap, and Surface Water in the Obuasi Municipality, Ghana. Human and Ecological Risk Assessment: An International Journal, 16(3), 651–665.

Soodmand Afshar, H., Doosti, M., & Movassagh, H. (2018). A Comparative Study of Generic Structure of Applied Linguistics and Chemistry Research Articles: The Case of Discussions. Research in Applied Linguistics, 9(1), 28-56.

Susanti, T., Utami, W., & Hidayat, H. (2018). The negative impact of illegal gold mining on the environmental sector in Batang Asai, Jambi. Sustinere: Journal of Environment and Sustainability, 2(3), 128-143.

Utomo, W. H., Suntari, R., Arfarita, N., & Handayanto, E. (2014). Rehabilitation of artisanal small-scale gold mining land in West Lombok, Indonesia: 3. exploration of indigenous plant species and the associated mycorrhiza for phytomycoremediation of mercury contaminated soils. American-Eurasian Journal of Sustainable Agriculture, 34-42.

Wahyudi, E., & Firdaus, F. (2018, November). The Impacts of Illegal Gold Mining Toward The Implementation of Farming Rice Based on The Ecological Dimension in Merangin Regency Jambi Province. In 4th International Conference on Food, Agriculture and Natural Resources (FANRes 2018). Atlantis Press.

Widowati, W., Sastiono, A., & Raymond, J. (2008). A Toxic Effect Metal Prevention and Tackling Pollution. Publisher Andi, Yogyakarta.

Yulianti, R., & Sukiyah, E. (2016). Nana Sulaksana. The Impact of Unlicensed Gold Mining Waste on Limun River Water Quality in Sarolangun Regency, Jambi Province. Bulletin of Scientific Contribution, Fakultas Teknik Geologi, Universitas Padjajaran, 14(3), 1-12.