



Research Article

TRACKING AND MANAGING CONFLICT RISKS ASSOCIATED WITH EXTRACTIVE INDUSTRIES, ENVIRONMENTAL AND SOCIAL IMPACT ASSESSMENT: CASE STUDY FROM THE D R CONGO

***Kalela, T.I., Musibono, D.E., Nsimanda, C.I., Gizanga, R.V., IKetshi, B.L. and Munkwomo, JRG.**

Department of Environmental Science, Fac. Science, University of Kinshasa, DRC

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Abstract

The D R Congo is a vast country of 2,345, 509 km², almost 100 million inhabitants. It is the second biggest country of Africa with 9 neighbouring countries. These are in the Eastern part Uganda, Rwanda, Burundi and Tanzania; in the North South Sudan and the Central African Republic; in the West the Republic of Congo, and finally Zambia and Angola in the South. The D R Congo is claimed to be a natural scandal for impressive natural resources such tropical rainforest of about 155 million hectares representing 50% of African forests, the second biggest River of the World after Amazon, with a huge potential of hydroelectric power. The soil is fertile with 80 million ha of arable soil and rich in minerals. Recent investigations have revealed huge reserve of oil and natural gases.

Keywords: DRC, conflict, industries extractives, ESIA

INTRODUCTION

Context and General information on D R Congo. The D R Congo is a vast country of 2,345, 509 km², almost 100 million inhabitants. It is the second biggest country of Africa with 9 neighbouring countries. These are in the Eastern part Uganda, Rwanda, Burundi and Tanzania; in the North South Sudan and the Central African Republic; in the West the Republic of Congo, and finally Zambia and Angola in the South. The D R Congo is claimed to be a natural scandal for impressive natural resources such tropical rainforest of about 155 million hectares representing 50% of African forests, the second biggest River of the World after Amazon, with a huge potential of hydroelectric power. The soil is fertile with 80 million ha of arable soil and rich in minerals. Recent investigations have revealed huge reserve of oil and natural gases. Different details from above table1 show that in the African Great Lakes Region, the DR Congo is the biggest country with impressive natural resources and with a low population density. Three of the neighbouring countries (Uganda, Rwanda and Burundi) are heavily populated with limited natural resources; these countries are war-like and regularly attack the eastern border of the D R Congo under various rebellion names (ADF-NALU, LRA, AFDL, RCD, CNDP, M23, FDLR, FNLA, etc.). The main question to be asked is why such rebel troops are attacking hosting countries? This seems to be a strategy of weakening the DR Congo Army to better exploit natural resources. This is obviously a survival and smuggling war and not for ethnicity (Musibono, 2019; Musibono, 2001). The methods used in this study are based on literature search, field investigations and desk study. Indeed, we have analysed various UN panel of Experts reports, National and international NGO and Scientist papers; directobservation during the UNEP post-conflict socio-environmental Assessment and many private consultancies in the mining sector and extractive workshops so-called extractive industries countrywide between 2002- 2019.

Extractive industries (best extractive workshops) in the D R C challenges

Main extractive industries better extractive workshops challenges are;

- Avoidance of natural resources depletion due to over exploitation;
- Energy demand;
- Sustainable poverty;
- Cyclic armed conflicts and wars;
- Corruption;
- Poor leadership at all levels.

Since 1885, after the Berlin International Conference on Congo Basin and the creation of the Independent State of Congo, Congo natural resources were opened to the international trade. In the 1920s, the mining industry started to support dominant power industries, especially Belgium, France and United Kingdom. Various minerals were channelled to these countries and local extractive workshops remain raw material suppliers. It is why the uranium used by USA to produce the first atomic bomb was from Shinkolobwe (Katanga, D R Congo). Since then, the International Community has decided to close this mining pit. The first conflict arose in 1960 after the Independence from Belgium. Belgian troops helped Katanga secession as proclaimed by Moses Tshombe and colleagues. It was the first time to see colonial power troops invading the colony territory. This can be explained by the fact that Belgian industries needed Congolese minerals (Hochschild, 2006). The hydropower (energy) potential is huge at least 100 GW; and the Inga complex on the Congo River concentrates 44 GW. Other energy potentials are nuclear power, wind, geothermal, biomass, solar energy. Despite these potentials, the country access to electricity remains very low (less than 9 % in cities and 1% in rural areas).

***Corresponding Author: Kalela, T.I.,**
Department of Environmental Science, Fac. Science, University of Kinshasa, DRC

The following Table 1 shows the D R C and its 9 - neighbouring countries with their main natural resources

Country	Surface area in km ²	Population size in millions inhabitants	Main natural resources	Comment
D R Congo	2,345,509	75.507 308	Cobalt, copper, colombite tantalum or Coltan, oil, diamond, gold, silver, zinc, uranium, coal, freshwater, timber, tungsten, germanium, tin, natural gas, arable soil, mega-biodiversity with high endemism, hydropower, geothermal potential, solar, wind, biomass energy potentials, etc.	Population density (P.D.) of less than 50 inhabitants per km ² , the D R C is a natural scandal in terms of natural resources. Unfortunately, its GDP is 500 USD per capita, a big paradox. The political alternative or change is not well integrated despite the fact that there is the limitation of mandate number (2 maximum). The trend is to change the constitution and there is no lead of Law. <i>D R Congo is regularly invaded by Uganda, Rwanda and Burundi's armies or rebel troops.</i>
Central African Republic	622, 984	5.166 510	Gold, diamond, uranium, timber, oil, hydropower	The population density is 9 inhabitants per km ² ; a lot of natural resources. A naturally rich country under wars between regions (North poor but with important oil reserve, and the south naturally rich (war for hegemony).
South Sudan	620, 000	11.090 104	Oil, freshwater, gold, diamond, livestock, agriculture, timber	The P.D. is 18 inhabitants per km ² in a naturally rich country (war for hegemony).
Congo-Brazzaville	342,000	4. 492 689	Oil, natural gas, potassium, lead, zinc, uranium, copper, timber	The P.D. is 14 inhabitants per km ² in a naturally rich country (war due to international market dynamism (France through TOTAL or Anglo American multinational through Chevron and SHELL. Life power regime and soft democratic transition remains dreams and illusions.
Angola	1,466 700	18.565 269	Oil, diamond, iron, phosphate, copper, pyrite, gold, bauxite, uranium	The population density (P.D.) per km ² is 14 inhabitants in a potentially rich country (political war and hegemony). No soft political transition.
Zambia	752, 614	14.222 233	Copper, cobalt, Zinc, lead, coal, gold, silver, hydropower	The P.D. 19 inhabitants per km ² in a potentially rich country. No war recorded. Democratic political change recorded.
Uganda	241,038	34.758 809	Copper, oil, cobalt, hydropower, calcite, salt, agriculture, fishing	The P.D. is 145 inhabitants per km ² . It is one of the highest in the region in a country with limited natural resources. Constant invasion of the D R Congo in the Beni-Ituri region with huge natural resources (oil, gold, diamond, timber). No political since the 1980s.
Burundi	27,834	10.888 321	Livestock, agriculture, tea, coffee.	The P.D. is 392 inhabitants per km ² . It is second naturally poorest country in the region, but highly populated. Difficult political change and there is trend for president to remain in power for life. Constitution arbitrary modifications.
Rwanda	26,338	12.012 589	Agriculture	The P.D. is 456 inhabitants being the highest population size in the region; it is the naturally poorest country of this region of Great Lakes of Africa. War for natural resources search in the D R Congo, and a sorrowful genocide related to ethnic hegemony. Considering its population density, Rwanda needs a lot of resources to secure its population. This naturally poor country has to find external resources from the big neighbour with impressive resources with weak and poor governance using various means including wars.
Tanzania	945,090	48.261 942	Tin, phosphate, iron, coal, diamond, gold, natural gas, nickel, hydropower	The P.D. is 51 inhabitants per km ² in a naturally rich country. With Zambia, Tanzania is the only country in the region with democratic political change. It is a peaceful country.

Source: Afrique Espoir, 2020.

Conflict risks associated with extractive industries

- Identification

The following map easily shows the conflict zones and its root causes.



Source: SMI- CSR presentation, 2014.

Description and analysis

On this map, intensive mining activities occur in the eastern part of the country (all black points), especially in the neighbourhood of Rwanda, Uganda and sometimes Burundi. The specificity of this region is the huge presence of gold, cassiterite, and colombo tantalite (coltan).

But also oil and gas reserves. In the southeast or Katanga region, mining activities require huge investment for extractive workshops. Indeed, the artisanal exploitation of gold, diamond, cassiterite and colombo tantalite (coltan) is easier than the exploitation of copper, cobalt, zinc, etc. This might explain why armed conflicts are more intensive in the northern zone of the D R Congo than elsewhere in the country. As stated in the introduction, Rwanda the most aggressive country is very poor in terms of minerals. There is no mining in the Rwanda despite the fact that this country is exporting minerals. They have to get from the rich neighbour by all means including the armed conflicts under diverse false reasons of ethnicity or democracy implementation. War lords quickly become mineral exporters. Rwanda is the first african exporter of coltan since 2008 despite the fact that there is no mining in Rwanda.

The following Table 2 shows the facts.

Table 2. Coltan export from Rwanda and D R Congo (2008-2012) in tonnes (metric)

Country	2008	2009	2010	2011	2012
Rwanda	922	952	560	829	900 (from wars in D R Congo; no mining operations Rwanda land)
D R Congo	509	490	279	383	261 (Very rich ore reserve)

Source: British geological Survey, 2014. World Mineral Production 2008-2012. Ed. Centenary, Keyworth, Nottingham, p.100.

So where does coltan come from? Of course, from the conflict zone of the D R Congo (Brown et al, 2014; Berouts, 2010; Assadho, 2006; Kassem, 2001; Musibono, 2019, 2001; Dietrich, 2002). The following issues are to be recalled:

1. Considering rebel troops, there is a strong paradox in the sense that these foreign troops attack hosting country locals

instead of attacking home country governments. Are they rebels against D R Congo? And why?

2. Considering minerals and other natural resources trade in the region, who is buying stolen minerals such as gold and coltan from Rwanda, a miningless country?

Weapons used by rebels are bought from mineral illegal trade. The following section is summarizing the map of Congolese mining countrywide. In 2008, 642 investors were sharing a total of 4531 mining permits either for research/exploration (3636 permits), or for exploitation (529 permits), as follows,

1) Copper and other minerals

- Katanga: 1070 permits for research/exploration and 66 permits for exploitation;
- Bas-Congo: 58 research/exploration and 0 permit for the exploitation;

2) Diamond

- Kasai Occidental (Western Kasai) and Oriental (Eastern Kasai) share together 810 permits for research and exploration and 41 for exploitation;
- Province Orientale: 420 permits for research and exploration and 4 permits for exploitation;
- Equateur: 105 research and exploration, and 9 for the exploitation;
- Bandundu: 186 permits for research/exploitation and 3 for the exploitation;

3) Gold

- The Kivus (Maniema, Sud and Nord-Kivu Provinces): 22 permits for the exploitation;
- Orientale : 262 permits for Research and exploration and 69 for the exploitation;
- Kasai Orientale: 58 permits for research/ exploration and 0 for the exploitation;

4) Tin and associated minerals

- Katanga: 403 permits for research and exploration and 2 permits for the exploitation;
- Kivus (Maniema, Sud and Nord Kivu provinces): 47 permits for the exploitation (Musibono, 2009; D R Congo, 2002; Banque Mondiale, 2008; Banro, 2013).

These numbers have increased significantly. For example, the sole Katanga Province has more than 200 operating mining Industries. These are polluting the environment without social value-added for local communities.

LOCATION, MATERIAL AND METHODS

Katanga mining province is the main study areas. We sampled water, sediment, air dust and industrial effluents from mining industries from the following sites: Canal Albert/Likasi, Chemaf/Lubumbashi, CMSK/Kipushi and Lulu/Kolwezi. These sites were investigated because of their intensive activities and risk of pollution. In the same areas, we also investigated on the main income-generating activities and also the social benefit from the mining industry. A total of 120 individuals randomly approached was investigated. The study was carried out between the 7/7/2009 and 26/8/2012 based on several field missions, ERGS being the CEMIC Consultant and partner. The social responsibility of mining companies was assessed through a specific questionnaire submitted to

investors and local communities. The 5 Key questions are the following:

a) For miners

- Q1. How long have you been working here?
- Q2. What have you done for the local communities development
- Q3. Do you think that you have invested enough in local development?
- Q4. Is there any conflict between your company and the local community?
- Q5. Have any further development plan? About what?

b) For the community

- Q1. Have you ever received any developmental assistance from this company exploiting minerals in your area?
- Q2. What kind of assistance have you received?
- Q3. Are you happy with this?
- Q4. What do you suggest?

Different answers revealed that:

1. Mining companies provide the assistance, unfortunately all interventions are humanitarian.
2. Local communities are not happy due to the fact that the poverty is increasing as minerals are exploited.

So beside the armed conflicts generated from neighbouring countries, internal conflict is mainly due to local poverty. They are also resistance forces against invaders. All of them are named 'mai-mai' troops conducted by local warlike lords.

Mechanisms for tracking and managing conflict risks

The mechanisms for tracking and managing conflict risks should be based on legal cooperation between the D R Congo and its warlike neighbours. Through this cooperation for economic security, all parties will benefit. Rwanda and Uganda for the export transit taxes and customs and DR Congo for the minerals. During the colonial era, Rwanda and Burundi were economically secured through the confederation Belgian Congo-Rwanda-Urundi. During that period, the manpower was easily moved from Rwanda to Congo in the mining provinces of Kivu (especially at Kalima in Maniema) and Katanga (at Kipushi for example). Indeed, being a small heavily populated country, the excess of the population was thus exported to the Congo (Hochschild, 2006). During Mobutu regime, an economic community was created, the so-called CEPGL (Economic Community of Great Lake countries). This was a good strategy to avoid resource-generated conflicts between Rwanda, Uganda, Burundi and the D R Congo (former Zaire).

Recommendations

Main recommendations are:

1. Resuming and promoting the CEPGL;
2. Promoting true democracy to improve the leadership;
3. Promoting the regional integration such as BENELUX, EU, SADC and opening of the borders for free trade and human migrations.
4. Creating the sovereign wealth fund from the benefit of natural resources trade to support alternative development projects in the region.
5. Daily monitoring of the latent conflict and its causes to prevent armed conflicts.

6. Ending dictatorial regimes in the region. Indeed, when we analyse all political regimes in the region, the common index is the dictatorship. No free elections are organised. All leaders are from armed conflicts and recycled through pseudo-democracy generating therefore frustrations, stresses. All regimes in the region are toxic (Musibono, 2012; 2009). If Rwanda is the most active warlike neighbour, Uganda through its rebel groups is invading the D R Congo (ADF-NALU, LRA) in gold-rich region of Beni and Ituri. Finally, the D R Congo needs strong dissuasive armed troops to be respected.
7. The implementation of the same kind of Kimberley protocol to control the traçability of minerals (transparency) is strongly recommended.
8. When peace agreements are not respected, countries illegally exploiting and trading the natural resources of the D R Congo should be punished. For example, financial assistance to these countries, especially Uganda and Rwanda should depend on their co-operation to promote peace. The UN panel of Experts recommended the same measures in 2001 (Kassem, 2001; Brown et al., 2014; Bakandeja, 2006; Dietrich, 2002).
9. Trade should be based on OECD standards in respect of legal standards and illegal trade should be banned.
10. The List of Companies and individuals involving in illegal trade of the DR C minerals and other natural resources should be published.

Part two: Environmental and social impact assessment

Mining industry is the most polluting human activity. This starts from research and exploration, through mining operations and metallurgy. All these activities generate various wastes with deleterious effects on humans and ecosystems. In the D R Congo, both small-scale mining and industrial mining are developed.

In this section, we are focusing on both.

Small-scale mining

According to legal regulations, environmental requirements related to artisanal mining and building material extraction (Title XVIII, Chapter I, Art. 404 - 414 and 417 in Règlement minier 2003), all miners should secure funds for the environmental rehabilitation. In practice, nothing is done accordingly. Indeed, youths struggling for daily survival do not pay attention to any regulation. The weakness of the Government to provide jobs is ne the big concerns. It is why, in most cases, these children exposed to toxic or radioactive pollutants do not care about health consequences. They generally respond that "it is better to die of cancer tomorrow instead of starving today". This more or less look like migrants dying in the Mediterranean sea 'graveyard'.

Potential and real impacts are reported in the following Table2.

Table 2. Potential and real socio-environmental impacts related to artisanal mining in the D R Congo


Activity	Mineral	Environmental and social impact	Comments
Exploration	Gold	Deforestation, habitat destruction, biodiversity threats	
Exploitation and use of chemicals	Gold	The use of the mercury (Hg) and cyanite (CN ⁻) is critical. Indeed, Hg is a heavy metal very toxic and bio-accumulates in food- chains. Consumers of exposed food are contaminated and might develop cancer, tumor, teratogenesis, abortion, cytotoxicity, etc. In 2007, at Muvungi site (Namoya/ Kabambare, D R Congo), we observed a wide use of the mercury and no live organisms were visible within dozens of kilometres downstream the mining site. The same figure is also reported from Kamituga, Mongbalu, Lugwisha, etc. where artisaal gold extraction is developed. In 2003, while heading the laboratory of Toxicology at INRB (National Institute for Biomedical Research) in Kinshasa, we received patients from Kisangani. They were Caritas International and Doctors without border workers. They were complaining to be have been poisoned by enemy troops during the war. All analyses revealed that they have high amounts of mercury, lead and cadmium in their blood and urine. The main source of contamination was the drinking water used. Indeed, as artisanal mining was occurring upstream, Tshopo river water was contaminated with this metal. Hosting monks were not poisoned because they were using spring water instead of the official supply water. Lead and cadmium were from older pipes.	
Gold ore processing with cyanite	Gold	Cyanite is toxic and inhalation of this chemical fumes negatively impacts lungs and might lead to blood poisoning.	
The exploitation and trade of gold		Create 'survival jobs', but also negatively impact education. Indeed, youths abandon schools for gold extraction. They generally feed the all families. They are exposed to above pollution and are exposed to death.	Another impact of artisanal mining is the cyclic armed conflicts occurring in the D R Congo. Indeed, all lord wars are involving in illegal mining as mentioned above. It is why most of conflicts are in the gold-rich regions of the D R Congo (Kivus and Ituri). This is a negative impact.
Artisanal extraction of diamond	Diamond	Physical impact on habitats and ecosystem integrity. The main pollution is the increase of the sediment in receiving rivers.	Social impact is like for the gold in terms of armed conflict generation. Local communities are getting poorer while lord wars are getting richer. This is one of the Congolese paradox.
Artisanal mining	Coltan, gold, diamond	Destructive for supporting ecosystems.	Increasing risk for sexually transmitted diseases through prostitution and youth rape. Generating or boosting local small businesses; increased life costs for locals (negative).

Industrial mining

As for the artisanal mining, environmental and social requirements are almost the same. But as artisanal mining has limited socio-environmental impacts, industrial mining is heavily polluting the environment. In theory, jobs are created, but in practice these are not sustainable in most cases. With toxic salaries, employees are dying of both pollution and sorrows/frustrations. Receiving water body ecosystems are under various threats. The main case of study is Tshituru in Likasi. Indeed, based on hydrometallurgical operations, acid waste waters heavily contaminated with heavy metals such as Cu, Co, Cd, Pb, Hg, Ni, Zn, etc. are discharged into Buluwo river through the Canal Albert. Our investigation in 2005, 2007, 2010 and 2013, revealed no sign of aquatic life in the Canal Albert and in the Buluwo river discharging into the Kapolowe river. All this ecosystem is heavily polluted. Deleterious impacts observed and analysed are reported in the following slides. As the opposite of the artisanal mining, the industrial mining requires more investments for extractive workshops. War lords are not able to sustain this. It is why Katanga province is more quiet than the Kivus and Ituri. The following slides from our presentation at SMI/ CSRM/ University of Queensland (2014) show the mining areas of the D R Katanga in the D R Congo and their impacts.

General Context – Mining in the Katanga Region

- A surface area of 496.871 km²,
- Total population (2010 est.) of about 5.6 million,
- Renowned as the 'jewel in the Congo's crown', Katanga is part of the copper belt mineral-rich region,
- Home for copper, cobalt, zinc, uranium, gold, etc.
- Has 34% of the world's cobalt reserves and 10% of world's copper,
- Major mining companies operating include Glencore, Freeport McMoRan, MMG, KCC, STL, etc



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Mining Impacts: Historical Background

- The concept of environmental impact was unknown before 1972.
- Since 1885, D R Congo natural resources have been exploited by King Leopold II through the « Société Générale », Belgium (1908) through « Union Minière », D R Congo (1960: Union Minière); then, since 1967, through « Gécamines » and actually through sliced Gécamines and numerous companies (called Gécamines partners or joint ventures),
- In 2013, Katanga hosted more than 300 companies (national and international) directly exploiting minerals,
- Prior to 2005, all these mining activities did not pay attention to the Environment and to the inside communities health. They were all exposed to massive pollution

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Since 2005,....

- In 2002, a mining Code was published; and in 2003 its regulatory book (« Règlement minier ») was launched.
- 2004, the World Bank recruited me as a Senior Consultant for the Environment to train the Mining Technical staff.
- During 30 days, I trained 35 mining engineers and inspectors on how to conduct ESIA, environmental audit/ Inspections and on how to elaborate the Socio-Environmental Management Plan.
- After the indoor theory, we went on the field works, and in 2005, ESIA policy was implemented.
- Since then, in theory, Nobody can be allowed to operate in mining without the ESIA report and its specific management plan.

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Legal procedures and mining permit

- The Ministry of Mines analyses application of interested miners to determine the size of concession requested.
- The size of the concession is expressed in number of mining quarries; 1 quarry = 84.995 ha), the location (GPS), the technical, human and financial capacity to realize the work. Of course, this might be for research or exploitation phase. When the research or exploitation permit is issued, then, the works can start.
- ESIA report and its management plan is required prior to the commencement of different mining works. (no permit is issued without ESIA report).
- ESIA is performed by an authorized consulting firm freely recruited by the Mining applicant.

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Concerns considered in ESIA

- Identify the environmental and socio-economic resources potentially affected by the project.
- Predict positive and negative impacts and the extent to which positive effects can be enhanced and negative effects mitigated.
- Quantify and assess the significance of effects where possible
- Consider the need to compensate for any significant residual negative effects
- Identify methods to mitigate and monitor resources that may be affected by the project.
- Prepare a management plan with all resources needed.

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ESIA explicitly targets:

- **Biophysical environment**
 - General landscape description
 - Climate
 - Biodiversity hotspots (both plant and wildlife): threatened or endangered species, endemism
 - Protected areas (if any): key biota or species protected
 - Ecosystem status
- **Social impact**
 - Main ethnic groups and population structure (population size, sex ratio)
 - Social organisation and social classes
 - Main income generating activities
 - Cultivated lands proportion
 - Main markets (local, regional and international)
 - Number and names of villages to be crossed by the corridor
 - Customary and beliefs
 - Social facilities in the area (schools, hospitals, churches)
 - Health history (historical outbreaks of some dangerous diseases, including sexually transmitted diseases such as AIDS/HIV)
 - Gender sensitivity
 - Historical heritage sites (if any)

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Operations during the mine building

- As deforestation has occurred, reforestation programme should be implemented as a psychological compensation (bill) for the environment.
- Noise (Individual protection for employees required).
- Dust (use of mask by the employees).
- Risk of being attacked by a wild animal, sensitization campaign to raise the awareness.
- Delocalisation, relocation, compensation (mutuelle).
- If cultural heritage is affected, negotiation with locals is recommended for a peaceful agreement to avoid conflict.
- Water and soil samples are analyzed to determine basic parameters such as pH, electrical conductivity, TSS, Turbidity, Cu, Cd, Pb, Hg, Co, Ni, As, Cr and U for water; and pH, Organics, Cations exchange, Cu, Cd, Pb, Hg, Co, Ni, As, Cr, and U for soil.



Result.. continued

Element/Location	Pb	Cd	Cu	Co	As	Zn	Ni	Cr
Water Lubumbashi	8.83±	0.13±	80±	8±	8.80±	2.7±	1.58±	6.11±
Air	0.21±	0.00±	18±	8±	0.01±	0.7±	0.12±	0.00±
Solids/tailing	0.05±	0.04±	3.5±	1.2±	0.2±	3.2±	0.06±	0.02±
Luflu/ Kailash	0.23	0.03	1.4	0.0	0.03	2.54	0.004	0.008
Water	15.18±	0.18±	107.5±	10.2±	2.25±	2.4±	3.70±	5.12±
Sediments	0.015±	0.009±	3.4±	0.016±	0.005±	2.2±	0.04±	0.01±
Air	0.4±	0.1±	20±	2.5±	2.8±	2.30±	6.11±	0.00±
National standards (during code of the D R Congo) effluents (mg/l)	0.5	0.1	1.5mg/l	N.A.	0.4	30	1.0mg/L	1.0
World bank values (mg/l)	0.1	0.1	0.8	N.A.	0.3	10	0.8	0.3



Exploitation – The Tshituru plant/ Likasi case (Katanga, DR Congo)

- Main activities: metallurgy to produce copper.
- They use both pyrometallurgy and hydro-metallurgy. We focused on hydro-metallurgy because it is the most polluting process. It uses strong acids such as sulphuric acid.
- We analysed effluents (waste waters) to determine the pH, the electrical conductivity, Cu, Cd, Hg, Pb, Ni, Co, As, Cr, and U content as well. These were from the « Canal Albert ».
- All values we got were higher than those for legal standards for Pb, Cd and Hg. All biological tests showed acute toxicity on 8-day old fish (*Gambusia affinis*) juveniles. Untreated effluents were 100% very toxic and they do not meet legal requirements.
- Mitigation measures advised were: Settling tank for dilution process, then constructed wetlands using *Vetivaria zizanioides*, *Pistia stratiotes* and/or *Water hyacinth Eichhornia crassipes*.



Result.. continued

- LC50 calculated using Dragstedt & Lang equation:
 $LC50 = [50(X2-X1) + (X1Y2 - X2Y1)] / (Y2 - Y1)$

Crude effluent (ml)	Dilution water (ml)	No. of fish individuals exposed	No. of dead individuals after 9-h exposure	% of death per concentration
100	0	15	15	100
80	20	15	15	87
60	40	15	10	67
40	60	15	4	27
20	80	15	1	7
0	100	15	0	0

Using Dragstedt & Lang model, the LC50 VALUE IS 55.33 ml of effluent.



View of the Canal Albert at 10km from the discharge point



Result.. continued

- From Karber equation: $LC50 = LLC - [\sum(axb)/N]$
- LC50 = 47 ml.
- We did not use the probit method, because we do this computer model yet.
- Note that differences between methods used are systematic. It is why, you should always mention which method you have used. And do not compare values from different methods.
- Differences are also due to the fact that exposed individuals got individual protection strategies and individual capacity of resistance against a given poison. =====> Dragstedt & Lang is more precise than Karber.



Results of chemical analysis

Tableau 1- Average concentrations of dissolved As, Cd, Cu, Co and Pb in water and air dusts from Katanga province (7/7/8- 15/8/2012)(N=3 samples per site)

Sites	Elements (in mg/L for water and in microgram/m ³ for air dust)						
	Pb	Cd	Cu	Co	As	Zn	Cr(VI)
Shituru/Likasi (Canal Albert)							
Water	9.63±	4.15±	30±	8±	4.56±	6.65±	2.58±
	0.32±	0.01±	0.20±	15	0.03±	1.1	0.18±
Solids/ tailing CMK	6.42±	4.11±	6.9±	2.3±	3.12±	1.5±	1.06±
	0.01±	0.01±	2.1	0.16	0.01±	0.1	0.02±
Air sample/ Kipushi (sampling 30min. x 4.47 m ³)	0.550±	0.06±	6.2±	1.3±	0.2±	8.4±	0.05±
	0.22±	0.04	2.4	0.34	0.01	3.2	0.02



Community development: TFM and MMG cases

- The TFM & MMG social development strategies include the following aspects:
 - Alignment of TFM & MMG programs with local, provincial and national development priorities
 - Building capacity among the local community in partnership with government and local NGOs for long-term ownership and sustainability
 - Addressing basic community needs and infrastructure such as potable water, access to health care, basic education and economic development
 - Creating employment opportunities and income generation for non-TFM employees through skills training, micro-credit facilities and agriculture extension support





All these details revealed that

1. The D R Congo is very rich country in terms of minerals and other natural resources. However, the poor governance and the weakness of the State and corruption are generating smuggling in the mining zones (Tsurukawa *et al.*, 2011; Musibono, 2009; 2006; Charbonnier, 2001):
2. The over-extraction of minerals is enhancing the poverty locally.
3. Artisanal mining is the main driving forces of cyclic wars.
4. Social initiatives by some mining companies are positively appreciated, but remain humanitarian and not sustainable.
5. Ecotoxicological survey and monitoring is strongly recommended in both small-scale and industrial mining activities countrywide.
6. The effective implementation of legal regulations and guidelines is strongly recommended.
7. Each mining company should have an operational Environmental Management System.
8. Common thoughts on minerals being a source of wars should be banned. D R Congo just needs to improve its leadership and therefore the governance.
9. Alternative sources for national wealth should be promoted such as agriculture, ecotourism, art products, etc. through the creation of the sovereign wealth fund.
10. Particular attention should be paid to scientific research and University developments.
11. The ongoing process of wars against corruption, predation and kleptocracy is a strong step towards the State of Law.

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