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Radiological Impact of Rössing Rio Tinto Uranium Mine

Contributions by

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EJOLT & CRIIRAD Report

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EJOLT aims to improve policy responses to and support collaborative research and action on environmental conflicts through capacity building of environmental justice groups around the world.

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Summary

This report is based on on site radioactivity measurements and laboratory analysis of soil, sediments and water samples taken in the vicinity of the Rössing Rio Tinto mine.

It raises concerns regarding the management and contamination caused by the radioactive waste rock dumps and the tailings dam, where almost all the waste from mining the uranium is deposited.

The **waste rock dump** is creating external irradiation and radon exhalation that is a risk to workers as well as tourists. Regarding water contamination, the team detected a significant increase of fluoride, nitrates and sulphates downstream of the mine. Sulphates and nitrates are an indicator of the leaching of waste rocks. The data also show an increase for arsenic, zinc, boron, radon 222, vanadium and zinc (factor of 9 to 35), Molybdenum (factor 85) and selenium (factor 131).

The highest impact concerns the uranium concentration that increased by a factor of 2155, from 0.2 µg/l upstream to 431 µg/l downstream. WHO recommendation for uranium concentration limit in drinkable water is now 30 µg/l. Keeping any freshwater drinkable in a desert country like Namibia is a key issue – even if the water is salty and not tapped yet.

The **tailings dam** is further causing aerial dissemination of radionuclides as wind gusts are carrying away radioactive particles. In all four samples of topsoil the radium 226 / uranium 238 ratio is between 2.3 and 5, indicating that this dust contains the finest fraction of the tailings (radioactive waste from the mills).

Also of concern is the risk of dam failure. This risk will be aggravated if plans of mining expansion go underway and an additional 200 million tonnes are deposited in the tailings dam (Rössing, 2011). As stated in their own expansion report "geotechnical stability [of the tailings dam] is expected to be sufficient but requires further confirmatory analysis" (Rössing, 2011, pg.33).

The team has also detected very high uranium concentration downstream of the tailings dam (between 554 and 3 164 µg/l) compared to 0.2 µg/l upstream of Rössing mine. Rössing has a network of dewatering wells and trenches designed to pump back the contaminated water of the tailings dam before it reaches the Khan river system. These findings question the efficiency of this system. It also raises the question: For how long are these pumping activities planned in the Closure Plan by Rössing? Uranium by-products contained in the tailings dam have a half-life of more than 75000 years (thorium 230).

The team has detected radioactive tailings on the parking area at Rössing which currently has a dose rate 6 times above natural background value (0.9 µSv/h compared to 0.15 µSv/h). This was communicated to Rössing's

management who responded that these levels "are of no cause of concern". However the ICRP (International Commission on Radiological Protection) states that all radiation exposure should be maintained as low as reasonably achievable. This is due to the fact that with exposure to ionizing radiation there is no safe limit. The highest is the value of accumulated dose, the highest is the risk of developing cancer on the long term. **Moreover there are concerns that radioactive materials could have been re-used in other areas of the mine.**

The main recommendations given by CRIIRAD and Earthlife Namibia are:

- Rössing should allow independent specialists like CRIIRAD have access into the mining facilities to carry out an independent monitoring of the mine. This should include detection of the re-use of radioactive material and checking the efficiency of the water pumping facilities.
- Rössing should provide CRIIRAD and Earthlife access to base-line monitoring data in order to further confirm the contamination of underground water and trace its evolution since the operation of the mine.
- An independent assessment of the stability of the tailings dam should be carried out.
- CRIIRAD recommends that the tailings and waste rock dump should be put undercover to avoid dust and radionuclides being transported with the wind and limit underground water pollution.
- The studies of the Social and Environmental Impact Assessment should be reviewed by independent experts.

Keywords

Uranium mining

Low Level Radiation

Waste Rock Dump

Arandis

Water contamination

Rössing Rio Tinto

Tailings dam

Khan River

Contents

Acronyms

CSO	Civil society organizations
EC	European Communities
EIA	Environmental Impact Assessment
EJO	Environmental justice organizations
LLR	Low Level Radiation
CRIIRAD	Commission de Recherche et d'Information Indépendantes sur la Radioactivité
SEIA	Social and Environmental Impact Assessment
SEA	Strategic Environmental Assessment
ICRP	International Commission on Radiological Protection

Foreword

Conflicts over resource extraction or waste disposal increase in number as the world economy uses more materials and energy. Civil society organizations (CSOs) active in Environmental Justice issues focus on the link between the need for environmental security and the defence of basic human rights.

The EJOLT project (*Environmental Justice Organizations, Liabilities and Trade*, www.ejolt.org) is an FP7 Science in Society project that runs from 2011 to 2015. EJOLT brings together a consortium of 23 academic and civil society organizations across a range of fields to promote collaboration and mutual learning among stakeholders who research or use Sustainability Sciences, particularly on aspects of Ecological Distribution.

The overall **aim** of EJOLT is to improve policy responses to and support collaborative research on environmental conflicts through capacity building of environmental justice groups and multi-stakeholder problem solving. A key aspect is to show the links between increased metabolism of the economy (in terms of energy and materials), and resource extraction and waste disposal conflicts so as to answer the driving questions:

Which are the causes of increasing ecological distribution conflicts at different scales, and how to turn such conflicts into forces for environmental sustainability?

1 Introduction

As a part of the EJOLT project, EARTHLIFE Namibia (Mrs Bertchen Kohrs) organised visits in areas located in the vicinity of two uranium mines in Namibia, especially near the Rio Tinto-Rössing uranium mine, one of the biggest open pit mines in the world.

This mine is located near the town of Arandis that was built by Rössing to house its workers.

In the course of an on site mission carried out between **September 22th and October 2nd 2011**, scientists from the CRIIRAD laboratory took radiation measurements in situ, and collected samples for laboratory analysis. The CRIIRAD laboratory is approved by the French Nuclear Safety Authority (ASN) to carry out radiation monitoring in the environment.

- 14 topsoil samples.
- 13 samples of surface sediments of the Swakop, Gawib and Khan rivers.
- 11 underground water samples.

Maps, detailed results of sample analysis and charts, are not included in the present report. They are available in the preliminary report at the following URL:

http://www.criirad.org/actualites/dossier2012/namibie/CRIIRAD-namibia-prelim.pdf

Solid samples have been analysed at the CRIIRAD laboratory in France (measurements performed by HpGe gamma spectrometry) and water samples have been monitored for main chemicals by LDA 26 laboratory in France and for radium 226 and radon 222 at the CRIIRAD laboratory.

CRIIRAD team (Christian Courbon and Bruno Chareyron) participated also in training activities and lectures in Windhoek and Swakopmund.

The collected data has been compared with the data provided by the mining company in the Environmental Impact assessments and CRIIRAD preliminary report has been discussed with local authorities, mining companies including Rössing and the inhabitants of Arandis and Swakopmund at various meetings being organised in Windhoek and Swakopmund between **April 10Th and 19th 2012**.

Additional questions have been sent by EARTHLIFE Namibia to Rössing management on November 29Th 2012 and very limited answers have been provided by Rössing in a letter dated January 16th 2013. Unfortunately Rössing decided not to share a lot of useful information in particular the data regarding the underground water monitoring since the pre-opening of the mine. Without this data, some of the interpretation of CRIIRAD's findings will remain limited. Nevertheless sufficient information has been collected for sharing our concerns with the general public.

The present report is summarising some of the findings of EARTHLIFE and CRIIRAD.

2 Radioactive waste rock dumps

Rössing uranium mining activities are producing huge amounts of waste rocks. These are ore or minerals that is displaced during mining operations without being processed.

CRIIRAD and EARTHLIFE Namibia discovered that one of the waste rock dumps is located on the banks of the Khan river (at the intersection with Dome Gorge) without appropriate fencing and without any confinement. In the picture below, the waste rocks have a blue colour distinct from the natural substratum, the blue line shows the Khan river bed. The river is usually dry but during heavy rain events water flows (almost every year).

Aerial view of one of the waste rock dump at Dome Gorge

View of the waste rock dump at Dome Gorge (picture taken from the Khan River, CRIIRAD, 2011)

The radiological impact of the waste rock dumps has to be studied in detail as CRIIRAD preliminary measurements show various impacts on the environment.

2.1 First impact of radioactive waste rock dump: external irradiation

The gamma and beta-gamma dose rates measured by CRIIRAD with an electronic dosimeter on contact of the rocks is well above background values: 37 µSv/h for the gamma dose (Hp10) to be compared to a local background value of 0,19 µSv/h and 130 µSv/h for the beta-gamma dose to the skin (Hp 0.07). This last value is about 1 300 times above typical background values.

Gamma radiation is very powerful and can travel through air at distances of dozens of meters from the source. At a distance of 150 meters from the waste rock dump, the ambient dose rate is still about 50 % above natural background (see table 1 below).

External irradiation from the waste rock dump in the Khan riverbed

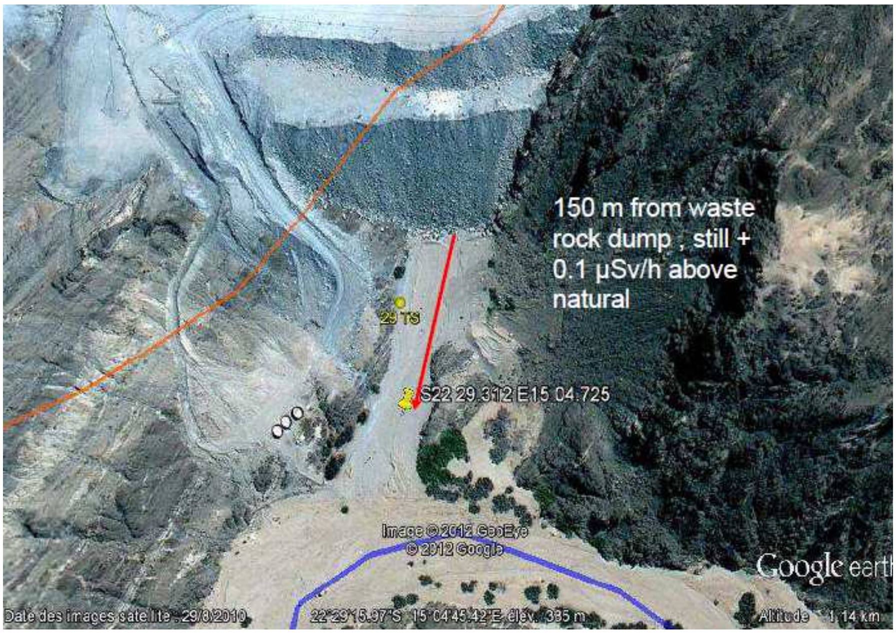


Table 1. Impact from external irradiation at the waste rock dump (Dome Gorge)

CRIIRAD measurements

Impact from external irradiation at the waste rock dump (Dome Gorge) / CRIIRAD measurements

Position	Gamma flux (c/s) DG5	Dose rate (µSv/h)	excess above Bkg (µSv/h)	Time for 10 µSv (hours)
Contact Rock N°1	15 000	37	36,81	0,27
1 m from Rock N°1	1 800	1,7	1,55	6
Rock N°2	1 300	1,00	0,81	12
25 m	600	0,47	0,28	35
50 m	500	0,41	0,22	46
75 m	450	0,39	0,20	49
100 m	400	0,38	0,19	52
125 m	400	0,32	0,13	78
150 m	360	0,29	0,10	98
impacted sediments (50 m from WD)	650			
Background (Khan river bed upstream)	180 to 230	0,19		

CRIIRAD team is monitoring gamma radiation rates and dose rates at the bottom of the waste rock dump (sept, 2011).

2.2 Second impact of radioactive waste rock dump: radon exhalation

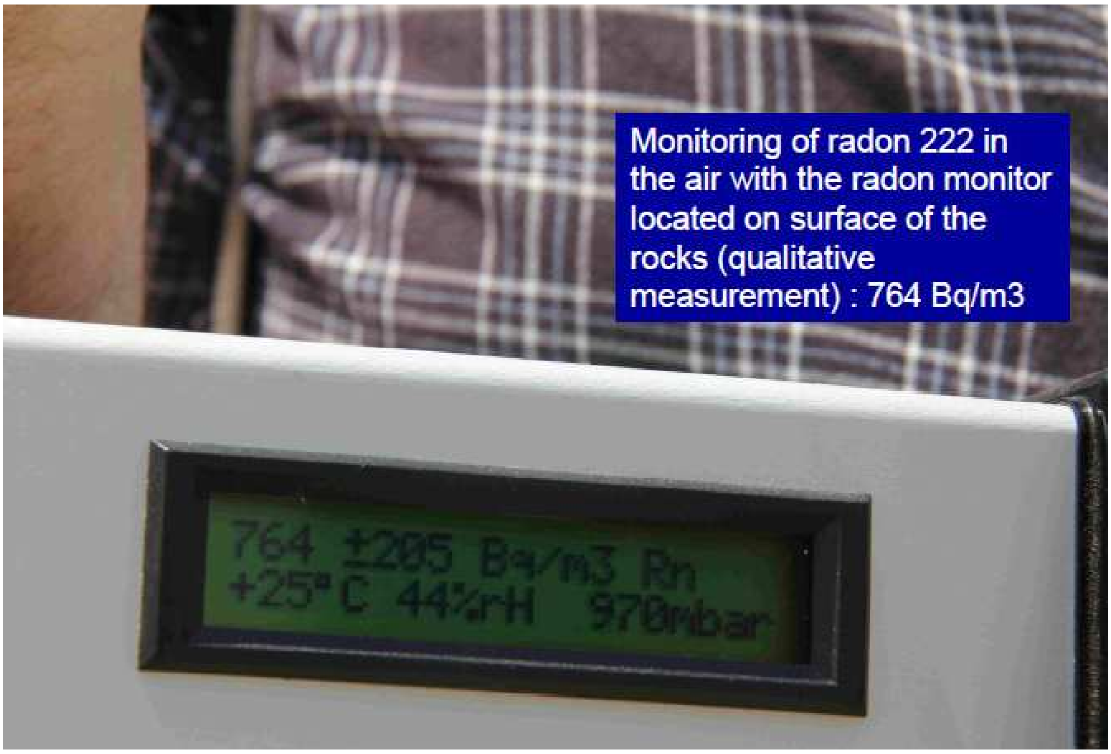
The waste rocks contain high levels of uranium in equilibrium with its decay products including radium 226. Radium 226 is continuously disintegrating and producing a radioactive gas called radon 222.

CRIIRAD performed a preliminary monitoring of **radon gas** activity in the ambient air near the waste rocks using an Alphaguard radon monitor. The results confirm high values of 722 Bq/m^3 (mean value) when the monitor is located on the rocks.

Radon and its short-lived decay products are carcinogenic to humans and are the second cause of lung cancer after smoking. There is no safe threshold, clearly demonstrated by epidemiological studies (see for example Darby et al., 2005).

The waste rock dumps are not covered so radon is continuously emitted by the rocks, transferred to the atmosphere and contaminating the area.

CRIIRAD team is monitoring radon in the open air, on rocks at the waste rock dump near the Khan riverbed



2.3 Third impact of radioactive waste rock dump: radionuclides in sediments

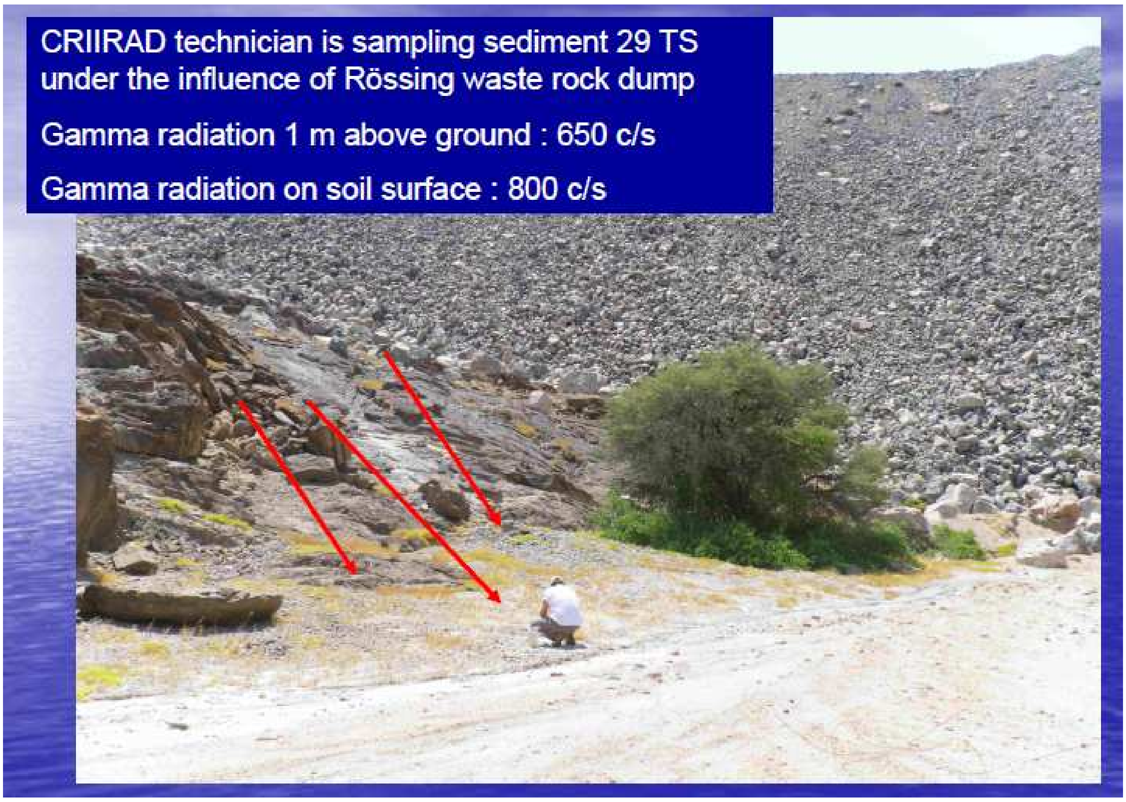
The finest fraction of the radioactive rocks is washed down and **contaminating the sediments** of the Khan river.

Due to the alpha emission by uranium and its by-products, the mineral matrix is progressively destroyed by the radiation. The fact that the rocks are now in contact with air and rain also changes the chemical reactions at the surface of the rocks and facilitates the dissolution of some of the radioactive heavy metals contained in the rocks.

This is illustrated by the laboratory analysis of sample 29 TS (picture below) in which uranium 238 activity is 1 200 Bq/kg and radium 226 activity is 1 400 Bq/kg.

These values are 10 times above those measured by CRIIRAD in sediments 31 S collected in the Khan river upstream from Rössing mine.

Sampling of fine sediments of the Khan riverbed at the bottom of the waste rock dump



Sampling of fine sediments of the Khan riverbed at the bottom of the waste rock dump

2.4 Forth impact of radioactive waste rock dump: radionuclides in water

The rain can also transfer the most mobile nuclides and chemicals to the underground waters. For this reason, CRIIRAD performed sampling of underground water from boreholes located in the Khan riverbed upstream and immediately downstream the waste rock dump.

Main results are plotted in table 2 below.

Table 2

Main results of underground water samples collected by CRIIRAD (Sept. 2011)

Sample Code (on site)	NA-30-E	NA-28-E	NA-26-E	NA-17-E	NA-36-E	NA-39-E
Lab Code	051011A9	051011A8	051011A7	051011A5	051011A10	051011A11
Location	Khan river (upstream Rossing and downstream bridge to Valencia	Khan river (downstream Rossing Dome Gorge waste rock dump)	Khan river (downstream Rossing - Panner Gorge)	Palmenhorst (near Swakop river, downstream confluence with Khan river)	near Swakop river (camel farm)	Arandis city
Water type	underground water / borehole DBH2	underground water / borehole K	underground water / borehole 16-A	underground water / Private well / (water sampled upstream water purification system)	Private well (no more used)	Tap Water inside a private house
pH	8,35	7,70	7,75	7,40	8,10	8,10
Conductivity at 20 ℃ (µS/cm)	7 464	6 998	3 009	8 405	15 654	1 603
Radon 222 (Bq/l)	< 4	37 ± 14	< 5	< 24	< 5	< 3
Ammonium **mg/l**	2,8	ND	ND	ND	ND	ND
Chloride (chlorures) **mg/l**	**2 963**	**1 882**	**805**	**2 668**	**5 627**	**364**
Sodium **mg/l**	**1 073**	**984**	**375**	**1 453**	**3 044**	**235**
Fluoride (fluorures) **mg/l**	ND	**2,4**	1,0	1,4	ND	0,53
Magnesium **mg/l**	234	142	67	208	285	27
Nitrates **mg/l**	ND	**98**	ND	**59**	12	16
Sulfates **mg/l**	ND	**1 302**	**336**	**998**	**1 755**	100
Métals / semi-quantitative evaluation by ICP / results in µg/l						
Al (µg/l)	6,9	6,4	5,0	1,6	8,5	3,8
As (µg/l)	0,1	0,9	0,1	0,8	3,4	5,1
B (µg/l)	46,3	**733**	258	**734**	**514**	281
Fe (µg/l)	**362**	20,1	42,3	33,4	20,4	9,6
Li (µg/l)	104	211	57,8	123	36,3	44,7
Mn (µg/l)	473	2,2	192	**679**	12,0	0,3
Mo (µg/l)	0,5	42,9	4,7	10,5	18,2	3,4
Ni (µg/l)	0,4	0,6	0,9	0,9	2,2	0,1
Se (µg/l)	0,1	**13,1**	0,4	9,3	**37,4**	1,5
Sr (µg/l)	5 740	5 050	1 930	5 790	9 780	1 360
U (µg/l)	0,2	**431**	**45,6**	**148**	**404**	16
V (µg/l)	0,3	10,5	0,4	10,2	12,3	14,4
Zn (µg/l)	4,1	29,1	2 900	0,9	24,0	29,5

Note : Figures in red are above WHO guidelines for drinking water

The analysis of the water samples show a very significant increase of the concentration of various chemicals downstream the waste rock dump at the confluence between Dome Gorge and the Khan river, when compared to upstream values.

As shown in table 3 below, an increase is detected for fluoride, nitrates and sulphates whose concentrations are below detection limits upstream. The impact is particularly high for sulphates (1 302 mg/l downstream). Sulphates and nitrates are an indicator of the leaching of waste rocks.

The data also shows an increase for arsenic, zinc, boron, radon 222, vanadium and zinc (factor of 9 to 35), Molybdenum (factor 85), selenium (factor 131).

But the highest impact concerns **uranium** (factor 2 155) whose concentration is **431 µg/l** downstream while it was only 0.2 µg/l upstream. WHO recommendation for uranium concentration limit in drinkable water is now 30 µg/l.

Table 3

Comparison of underground water characteristics upstream and downstream the waste rock dump at Dome Gorge

Sample Code (on site)	NA-30-E	NA-28-E	
Lab Code	051011A9	051011A8	
Location	Khan river (upstream Rossing and downstream bridge to Valencia	Khan river (downstream Rossing Dome Gorge waste rock dump)	
Water type	underground water / borehole DBH2	underground water / borehole K	Ratio Downstream / upstream
pH	8,35	7,70	
Conductivity at 20 ℃ (µS/cm)	7 464	6 998	
Radon 222 (Bq/l)	< 4	37 ± 14	**> 9**
Chloride (chlorures) mg/l	**2 963**	**1 882**	
Sodium mg/l	**1 073**	**984**	
Fluoride (fluorures) mg/l	ND	**2,4**	**Increase**
Magnesium mg/l	234	142	
Nitrates mg/l	ND	**98**	**Increase**
Sulfates mg/l	ND	**1 302**	**Increase**
Al (µg/l)	6,9	6,4	
As (µg/l)	0,1	0,9	**9**
B (µg/l)	46,3	**733**	**16**
Fe (µg/l)	**362**	20,1	
Li (µg/l)	104	211	**2**
Mn (µg/l)	473	2,2	
Mo (µg/l)	0,5	42,9	**86**
Ni (µg/l)	0,4	0,6	
Se (µg/l)	0,1	**13,1**	**131**
Sr (µg/l)	5 740	5 050	
U (µg/l)	0,2	**431**	**2155**
V (µg/l)	0,3	10,5	**35**
Zn (µg/l)	4,1	29,1	**7**

Recommendations

According to Rössing's SEIA (Social and Environmental Impact study), the external irradiation from the waste rock dumps "*is not considered as members of the public will not have access to such areas during mine operation*" (Rössing, 2011)

However as indicated in other sections of the SEIA: "*The Khan River is an important tourist view corridor and should not be subjected to landscape modifications. The existing vista does include close views of the existing waste rock dumps"* (Rössing, 2011).

From a radiological point of view, the access to the waste rock dump should be restricted. At a meeting with Rössing management in April 2012, CRIIRAD and Earthlife asked that a fence be built in front of the waste rock dump in order to lower the risk of the public being exposed to radiation.

Acknowledging this demand, Rössing stated that "*a fence has been erected to prevent unauthorised access into the mining licence area" (Response from Rössing* January 16th 2013)*.*

As shown in table 1 above, spending only 20 minutes at the bottom of the waste rock dump on contact with some of the rocks will give a dose in excess of the trivial level of 10 microSieverts. These results show as well that the workers inside the mine are continuously exposed to radiation from the ore bodies and waste rocks.

In order to evaluate the global risk for the public and workers, two other exposure pathways should be taken into consideration: the internal exposure to radioactive dust and radon gas and the risk of ingestion of radionuclides in case of direct contact with the rocks. People should also be prevented from bringing home radioactive rocks[1], because in this case the duration of the exposure may be much longer than a few minutes.

The appropriate disposal of radioactive waste rocks should be addressed by Rôssing. It is suggested that waste rocks should be deposited in a place with a minimum of confinement below the rocks and covered with layer of clay or any other material that would limit erosion, lixiviation by rain, radon emissions, etc.

This issue is extremely important, especially taking into consideration the fact that Rössing expansion projects would lead to approximately 250 million tons of additional waste rock requiring disposal (Rössing, 2011). The contamination will be everlasting since uranium 238 half-life is 4.5 billion years

[1] CRIIRAD documented a case in France where a citizen was keeping in his garden a piece of rock from a uranium mine. The doserate was 1 milliSievert per hour on the rock (5 000 times above local natural background) and 18,3 microSieverts per hour at a distance of 1 meter (about 90 times above natural background). Spending 10 minutes per day at a distance of one meter would give an annual dose in excess of the maximum annual dose limit of 1 milliSievert. CRIIRAD informed the authorities and AREVA had to remove the radioactive rocks.

Picture showing the expansion of the waste rock dump (Source: Rössing, 2011)

3 Impacts of Tailings

Once the uranium ore is separated from the waste rocks, it is crushed and processed at Rössing's uranium mill. The end product is uranium concentrate (yellow cake) but this activity is also producing huge amounts of radioactive tailings which are stored without proper confinement on a tailings dam.

Radioactive tailings contain chemicals and radioactive substances (some residual uranium and most of uranium's by-products including long-lived thorium 230 and radium 226). Typically, about 80 % of the initial radioactivity of the uranium ore is left in the tailings (Chareyron, 2008). That is why it is extremely important to isolate the tailings from the biosphere in order to prevent long term contamination through atmospheric transfer of radioactive dust and radon gas and through liquid transfer to the water table.

View of Rössing's tailings dam (CRIIRAD, sept 2011)

3.1 First impact of tailings dam: aerial dissemination of radionuclides

CRIIRAD discovered that the finest fraction of the tailings dumped on Rössing tailings dam is blown away by the wind and contaminates the surrounding environment as shown by the contamination of top soil plotted on the graphs hereafter.

Radium 226 activities range between 960 Bq/kg and 7 400 Bq/kg in soil samples 1T, 20T, 23T and 24T collected up to 2 km away from the tailings dam fence. Contaminated top soil also contains high levels of thorium 230 (8 600 Bq/kg in sample 1T). As can be seen on some of the pictures (below) the contaminated dust is fine grained and therefore easily inhaled. In the picture at the bottom one can notice that the dust has been accumulating at the bottom of a small bush which is probably “catching” the contaminated aerosols.

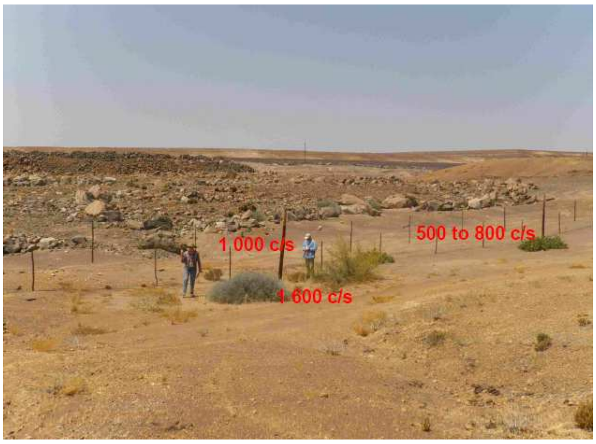
In all four samples of top soil the radium 226 / uranium 238 ratio is between 2.3 and 5. This indicates that the material dispersed by the wind is not made of dust from natural uranium bearing rocks but consists of the tailings that are radioactive waste from the mills where uranium 238 has been extracted from the ore. In this case, the uranium 238 residual activity in the waste is lower than the radium 226 activity.

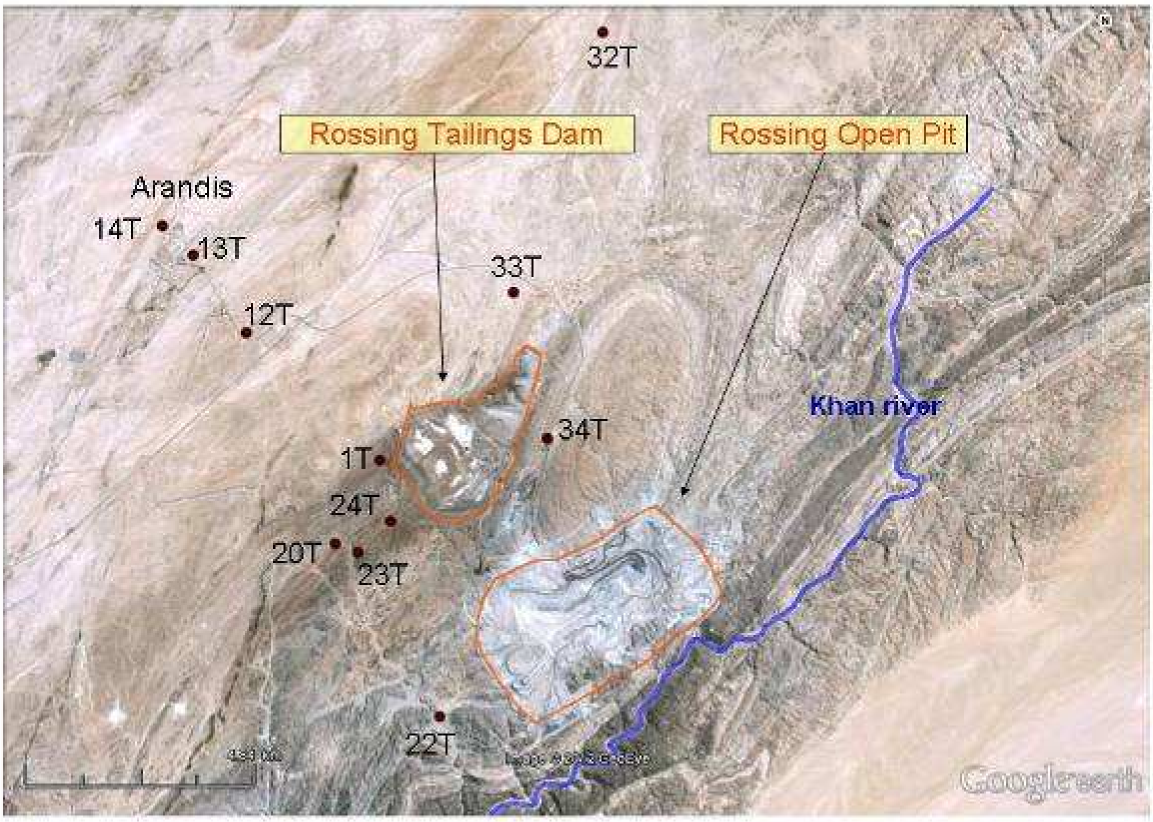
This impact is not properly addressed by Rössing. In a letter to EARTHLIFE Namibia dated January 16th 2013; Rössing states: “*No health risk is associated with the dust plume, which will be cleaned up as part of mine closure. Dust emissions are monitored continuously as part of the public exposure protection programme*”.

If such a cleaning is performed in a few decades when the mine closes, the contamination will persist since then. Some of the nuclides contained in the dust are extremely radiotoxic. For example, thorium 230 is one of the most radiotoxic nuclides especially in case of inhalation.

The lack of confinement of such radiotoxic substances is not acceptable. As with the waste rock dump, the tailings dam should be designed with a minimum of confinement and covered with a layer of clay or another cover that would limit erosion, lixiviation and emissions.

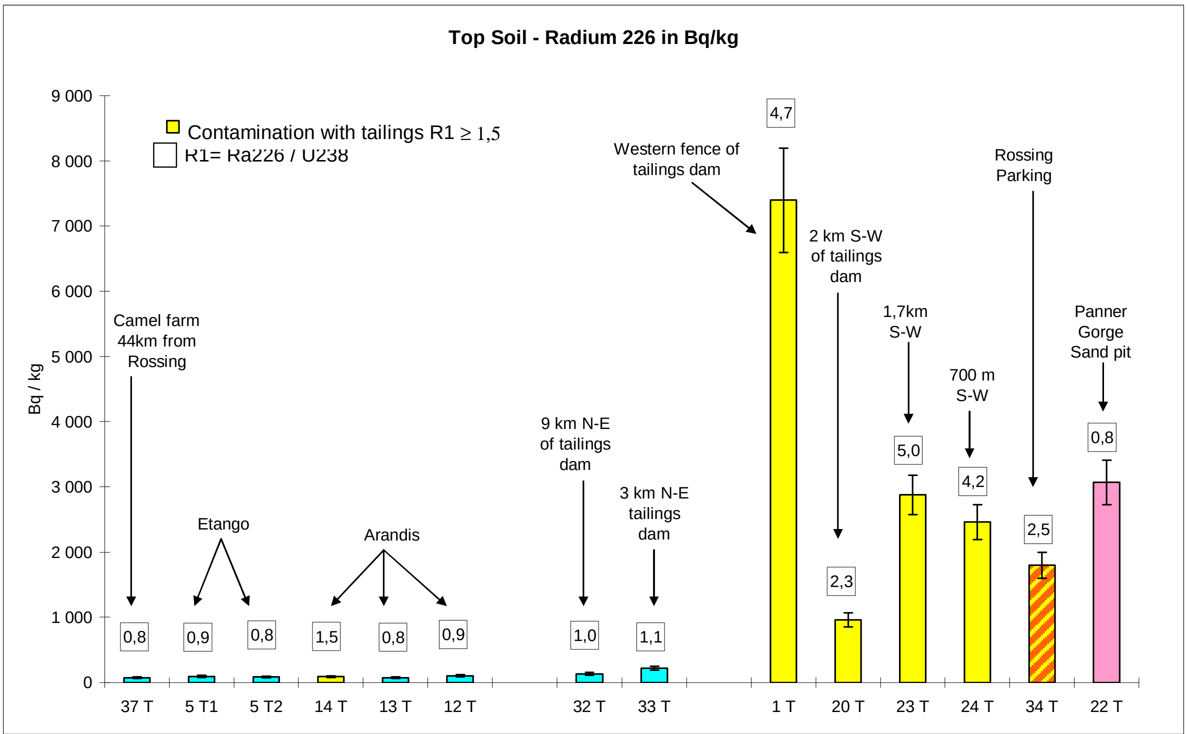
CRIIRAD team is monitoring gamma radiation in the surrounding area of Rössing's tailings dam and sampling contaminated top soil (CRIIRAD, sept 2011)





Map 1

Location of topsoil samples collected by CRIIRAD (Sept. 2011)



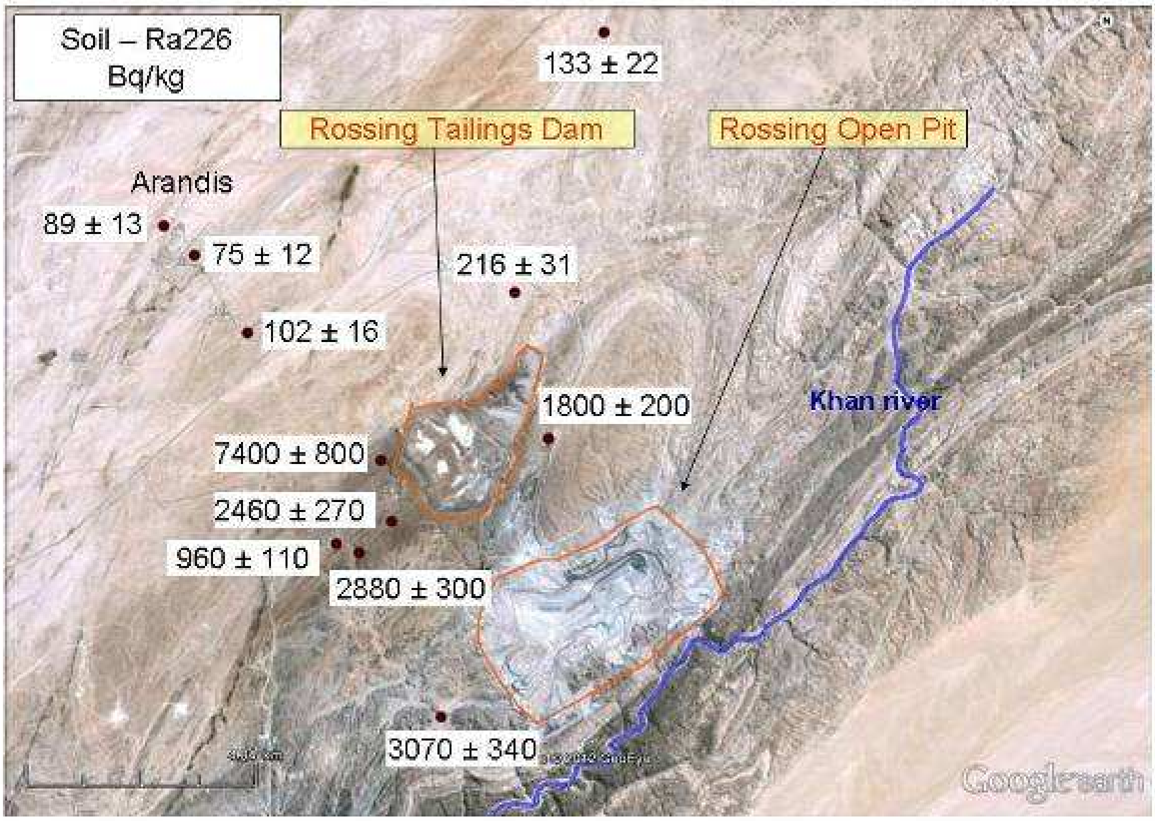
Graph 1

Radium contamination (Bq/kg) of top soil samples and radium226/uranium 238 ratio (see figures in each square)

Samples collected by CRIIRAD (Sept-Oct 2011)

Map 2

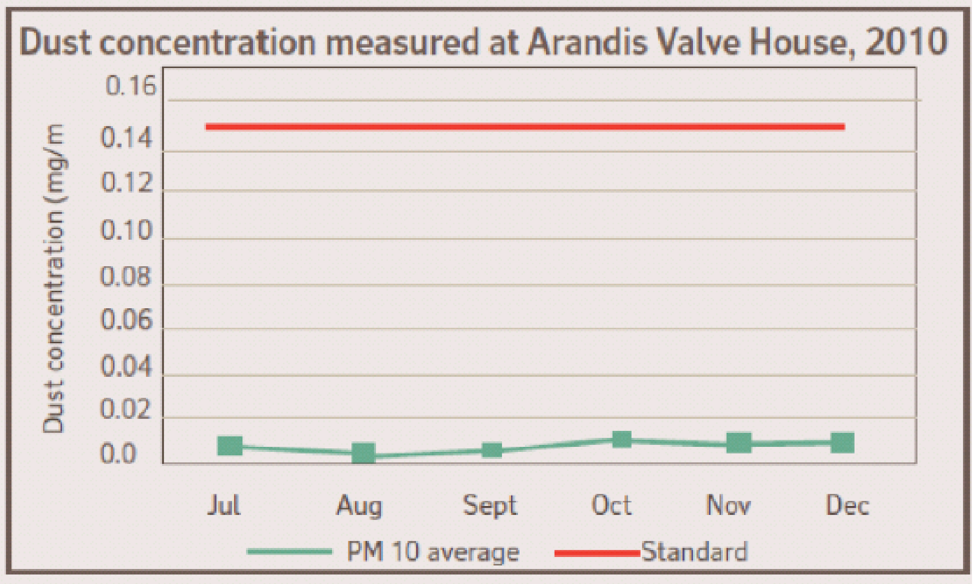
Radium 226 activity in topsoil samples (zoom near Rössing mine)



CRIIRAD scientists are not the only ones concerned with the impact of this radioactive plume. This point was also raised by Krugmann (2010) in the Strategic Environmental Assessment associated to the "Central Namib Uranium Rush": "Windblown dust from the dry parts of the tailings presents a significant environmental concern in the vicinity of the tailings. As the dust deposition plume around the Rössing tailing impoundment indicates tailings dust deposition can take place within a radius of 5-10km even in the direction of the strongest winds".

Regarding the dust monitoring activities performed by Rössing in the city of **Arandis**, some of the results are given below. One may notice that the values seem extremely low while compared to a "standard" whose value is set by Rossing above 0,14 mg/m^3 which is above 140 µg/m^3.

Graph 2 / Rossing web site : dust concentration monitored in Arandis, year 2010



In fact, WHO standard for inhalable particulates is 20 µg/m^3 for “annual average concentration” and 50 µg/m^3 for “Maximum 24 hour concentration”.

In the case of Arandis, the hazards caused by these particulates is enhanced by the fact that they contain radioactive substances.

3.2 Second impact of tailings dam: uncontrolled re-use of tailings

The dose rate measured by CRIIRAD on the **parking of Rössing mine** is about 6 times above natural background value (0.9 µSv/h compared to 0.15 µSv/h).

A video showing these measurements is available at the URL below:

http://www.criirad.org/actualites/dossier2012/namibie/mines.html

This radiation is due to the presence of radioactive tailings from Rössing mill as the analysis of top soil (sample 34 T) performed by CRIIRAD shows a radium 226 / uranium 238 ratio of 2.5. Uranium 238 activity in the sample is 730 Bq/kg while radium 226 activity is 1 800 Bq/kg.

In a letter dated January 16th 2013 sent to Earthlife Namibia, Rössing managing director states: “*Although the Radiation Safety Section at Rössing did not know that tailings have been used in the parking area, the “elevated levels” are indeed known to the Radiation Safety Section, and Rössing maintains they are no cause of concern as they do not result in significant additional exposure to anyone*”.

CRIIRAD considers that it is a concern to discover that Rössing Radiation Safety Section is not trying to understand the reason why levels of radiation are about 6 times above normal. This demonstrates a failure in the application of radiation protection principles. The first principle given by the ICRP "International Commission on Radiological Protection" is that people exposure to radiation should be maintained as low as reasonably achievable. This is due to the fact that, with exposure to ionizing radiation, there is no safe limit. The highest is the value of accumulated dose, the highest is the risk of developing cancer on the long term. It is agreed at international level that a trivial dose is a dose below 10 microSievert per year. In the case of the Rössing parking, spending 5 minutes per day during 200 working days gives an additional exposure in excess of 10 microSieverts. This is considered a "significant exposure". When adding the contribution of internal exposure by inhalation of radon emitted by the tailings and by inhalation of radioactive dust, the impact is even higher.

In the same letter, Rössing confirms that they are not planning to decontaminate the parking. The letter states: "*There is no plan for any modification of the area*." And *"Occupational exposures of workers in the area are monitored continuously and are consistently below 2 mSv par annum, all pathways included".*

CRIIRAD considers that the radiation received by the workers on the parking is very probably not taken into consideration in Rössing evaluation of doses since the workers receive their radiation monitors after entering the gate of the facility.

Moreover there is the concern that tailings or other radioactive material could have been used to build additional facilities within the mine affecting again the principle of diminishing exposure to radiation. CRIIRAD or an independent monitoring team should be allowed inside the mine to carry out a survey.

3.3 Third impact of tailings dam: risk of dam failure

In case of a failure of the tailings dam, huge amounts of radioactive material may contaminate the area. CRIIRAD noticed that there is no scientific report addressing the question of the stability of the dam in Rössing's expansion SEIA.

In a letter dated January 16th 2013 sent to Earthlife Namibia, Rössing managing director states: "*A stability study is in place for the present facility for a number of years. The risk failure is very low".*

CRIIRAD considers that Rössing is therefore acknowledging that there actually is a risk of failure. This risk may probably be increased with the expansion project when about **200 million tons of tailings** will be accumulated on the tailings facility as acknowledged in their expansion project (Rössing, 2011, pg 33) in which they state that "Geotechnical stability: is expected to be sufficient but requires further confirmatory analysis".

CRIIRAD considers that the Namibian authorities should require a detailed technical report about these issues including a review by a team of independent scientists.

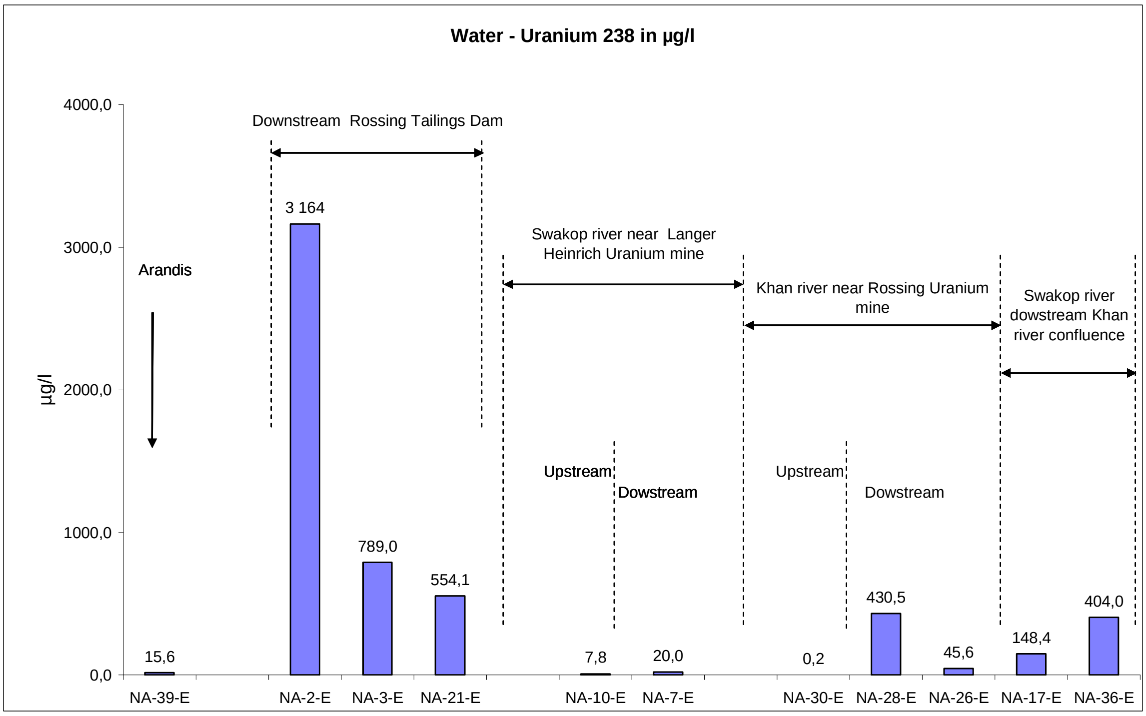
4 Long-term contamination of underground water

The high uranium concentration in underground waters collected by CRIIRAD downstream Rössing uranium mine in the Khan river and Swakop river alluvium raises the question of the origin of this uranium (see graph 3 and map 3 below).

Graph 3

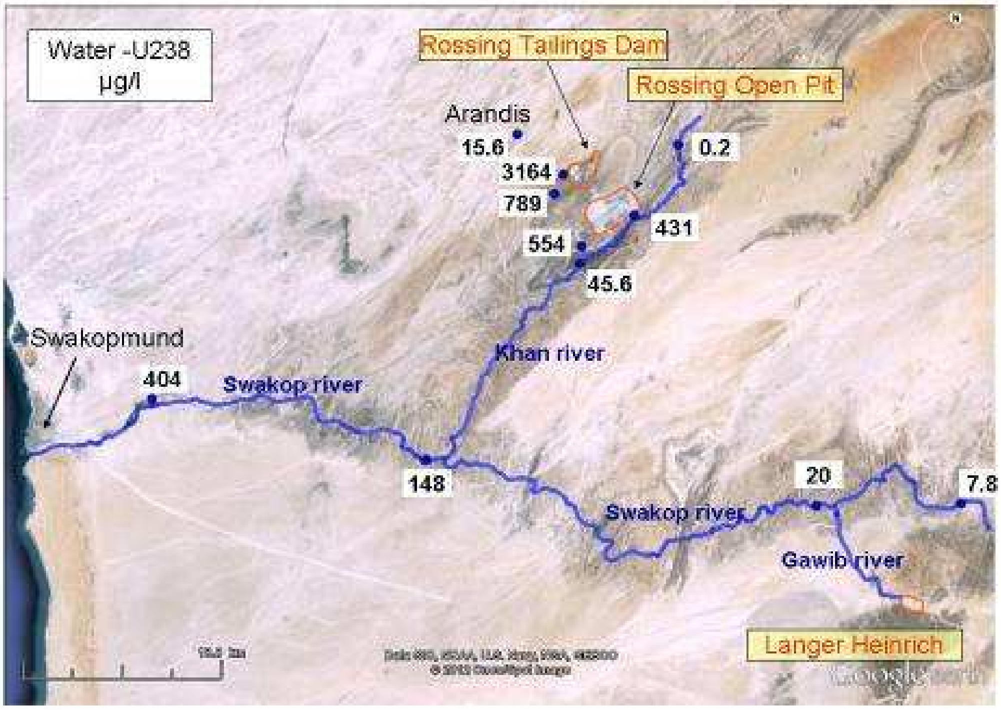
Uranium concentration in underground water samples

Samples collected by CRIIRAD (Sept-Oct 2011)



Map 3

Uranium concentration in underground water samples collected by CRIIRAD



In the Khan river uspstream from Rössing Mine and in the Swakop river upstream the confluence with the Gawib river (Langer Heinrich mine potential influence), the uranium 238 concentrations are quite low (0.2 µg/l and 7.8 µg/l respectively). The uranium concentration downstream of the tailings dam is very high (between 554 and 3 164 µg/l).

The impact can occur through leakages occurring below the tailings dam and as discussed in section 2, through the waste rock dump (where uranium[2] concentration is 430 µg/l). Both impacts have to be studied in detail.

Of huge concern is that the waste rocks and the **200 million tons of tailings** will constitute – on the long term - a source of chemical contamination (especially sulphates) and radioactive contamination of the Khan river basin. Surprisingly the modelling performed by experts paid by Rössing indicates that it will take 50 to 1 000 years for the contaminated plume to enter the Khan river (Rössing, 2011, pg 133). However, CRIIRAD's results described in section 2 show that the **contamination with sulphates, uranium and other chemicals is already detected in the underground water sampled in boreholes in the Khan riverbed.** The studies of the SEIA should therefore be reviewed by independent experts.

[2] The WHO guideline for drinking water is 30 µg/l (provisory value).

Rössing has a network of dewatering wells and trenches designed to pump back the contaminated water below the tailings dam before it reaches the Khan river system (see pictures below)

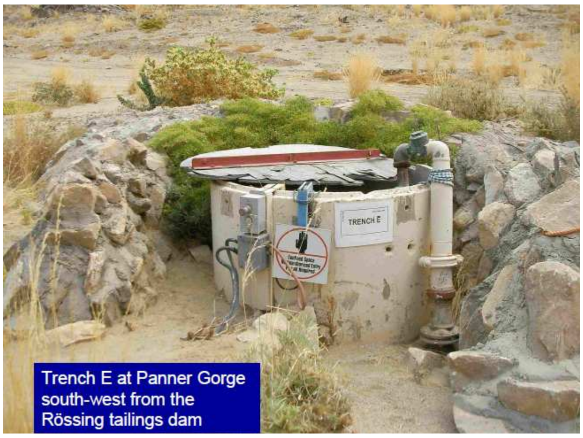
These findings question the efficiency of this system. Moreover, the present and future extension of the contaminated plume and the durability in time of the pumping activities is not properly documented in Rössing's SEIA. These questions should be raised by the Namibian authorities and demand an independent study of the origin of the extent of the contamination and the efficiency of the pumping activities.

For how long are these pumping activities planned in the Closure Plan by Rössing? Uranium by-products contained in the tailings dam have an activity of more than 75000 years (thorium 230).

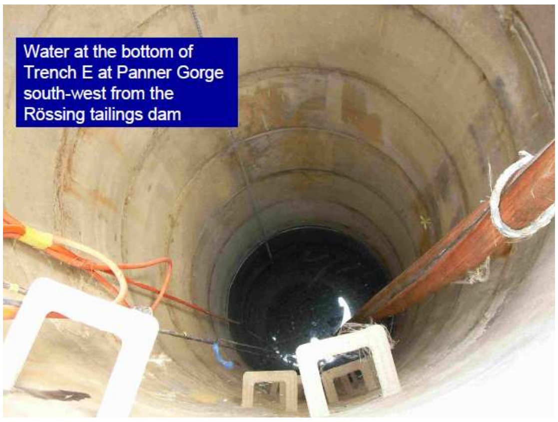
Dewatering wells and trenches designed to pump back contaminated water to the tailings dam


CRIIRAD technician is sampling water from a borehole PA 6 near the Rössing tailings dam

Rossing Dewatering Well N'DW 14 near the Rössing tailings dam



Trench E at Panner Gorge south-west from the Rössing tailings dam


Water at the bottom of Trench E at Panner Gorge south-west from the Rössing tailings dam

5 Conclusions

The main concerns raised by this report are the impacts of the waste rock dumps and the tailings dam, where most of the waste from the mine is deposited.

The waste rock dump is creating external irradiation and radon exhalation that is a risk for both workers and tourists passing by. Additionally radionuclides and other contaminants such as sulphates have been found in the underground water of the Khan River. Although this river is not currently used for human consumption due to high salinity, it should not be polluted chemically and radioactively.

The tailings dam is provoking aerial dissemination of radionuclides. Of great concern is the fact that tailings have been found in the Rössing parking area. This raises the concern that this practice could have also occurred in other areas in the mine therefore increasing the exposure of workers for no reason, which breaches the ICRP principle of optimisation of exposure to radiation.

Also of concern regarding the tailings dam is the risk of dam failure that will be aggravated with the addition of 200 million tonnes if plans of expansion go underway.

The main recommendations given by CRIIRAD and Earthlife Namibia are:

- Rössing should allow independent specialists like CRIIRAD have access into the mining facilities to carry out an independent monitoring of the mine. This should include detection of tailings being re-used and checking the efficiency of the water pumping facilities downstreaming the tailings dam.

- Rössing should provide CRIIRAD and Earthlife access to base-line monitoring data in order to further confirm contamination of the underground water of the Khan River.

- An independent assessment of the stability of the tailings dam should be carried out.

- CRIIRAD recommends that the tailings and waste rock dump should be put undercover to avoid dust and radionuclides being transported with the wind and limit underground water pollution.

- The studies of the SEIA should be reviewed by independent experts.

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