

## Preliminary investigation

### about the radioactive contamination in Jadugoda.

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#### . Purpose

Jadugoda is located in Jharkhand, Bihar state, and is the only uranium mine in India. It supplies the fuel to 13 nuclear power plants that are under operation in India at present. There is some information that the serious radioactive contamination was occurred around Jadugoda and inhabitants were damaged in their health.

Because I myself could not go to Jadugoda immediately, so I have done the preliminary investigation under the cooperation of Jadugoda people.

The map of Jharkhand and Jadugoda is shown in Figure 1.



Figure 1 The map of Jharkhand and the location of Jadugoda

## .The method of investigation

The following two kind of measurement was done.

### 1. Measurement of air gamma dose by TLD

24 TLD(thermo-luminescence dosimeter) were sent to India from Japan and were exposed in the field about 3 months. Then they were recovered and accumulated gamma-ray dose were measured.

### 2. Measurement of radioactive concentration in the soil

The soil samples were collected at where TLD were placed. Then they were sent to Japan and radioactive materials such as uranium were measured by the Ge semiconductor detector.

TLD arrangement places (the sampling points of the soil) map is shown in Figure 2. And, the date when soil samples were collected, the weight of samples and so on are shown in Table1.

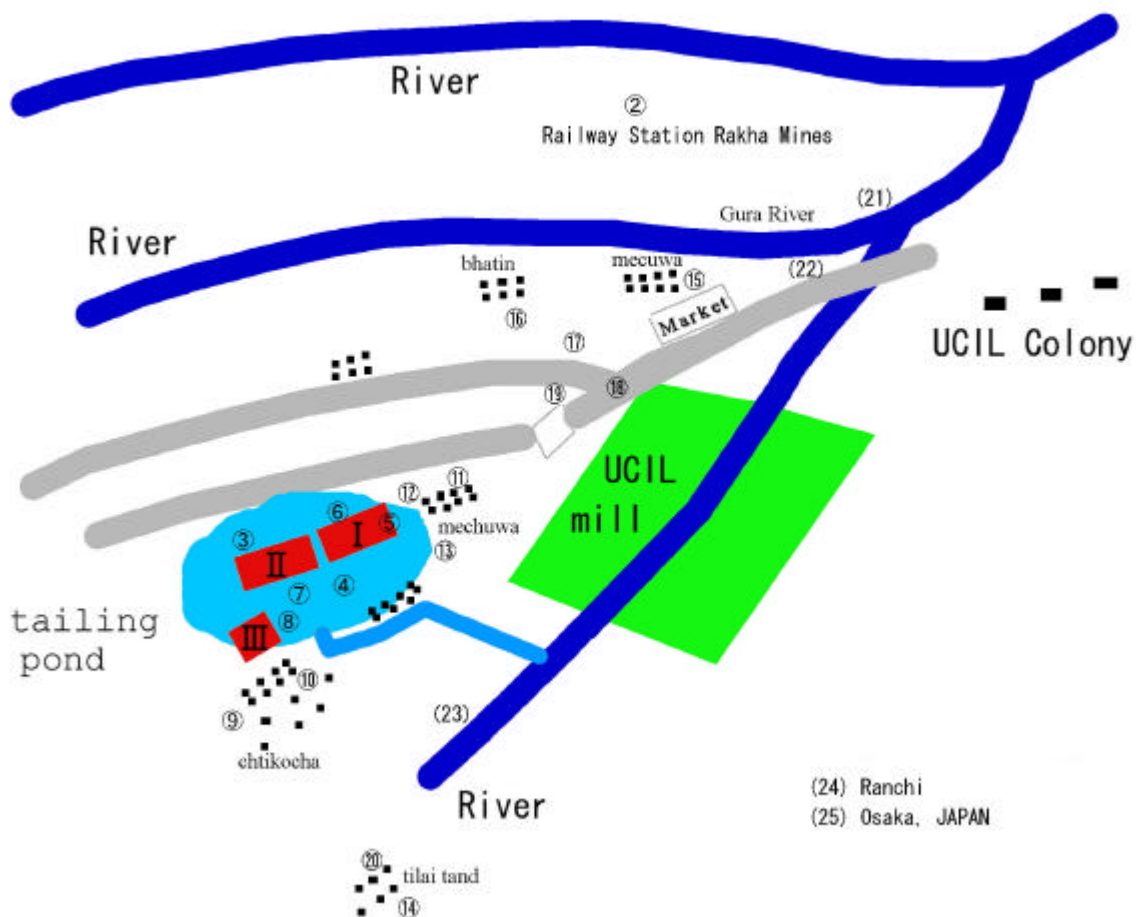


Figure 2 Location of the soil sampling and TLD arrangement

Table 1 Sampling points, date and weight of soils

	Location	sampling date	Weight [g]
<b>Mines</b>			
2	from railway station rakha mines	11.10.2000 at 6.30 p.m.	100
<b>Tailing Ponds</b>			
3	near tailing pond	11.10.2000 at 5 p.m.	136
4	near tailing pond	11.10.2000 after 5 p.m.	114
5	near tailing pond	11.10.2000 after 5 p.m.	125
6	tailing pond no. 1	11.10.2000 at 7 p.m.	135
7	tailing pond no. 3	11.10.2000 after 7 p.m.	154
8	tailing pond no. 2	13.10.2000 at 9 a.m.	104
<b>Villages</b>			
9	village chtikocha near ratan's house	12.10.2000 at 11 a.m.	127
10	village chtikocha near ishwar's house	12.10.2000 after 11 a.m.	159
11	village mechuwa(dugridh) near prabhat baske's house	12.10.2000 at 12 a.m.	122
12	village mechuwa(tuare dugridh) near futani tati's house	12.10.2000 after 12 a.m.	125
13	village mechuwa(tuare dugridh) near tati's house	12.10.2000 after 12 a.m.	168
14	village tilai tand near pulin banra's house	12.10.2000 at 3 p.m.	132
20	village tilai tand near tapash's house	12.10.2000 at 4 p.m.	128
15	village mecuwa near mirja shoren's house	12.10.2000 at 2 p.m.	135
16	village bhatin near gundi hembrom's house	12.10.2000 after 3 p.m.	113
<b>Road or River</b>			
17	near high school jadugoda	12.10.2000 at 2 p.m.	121
18	the main crossing road near jagdish bastralaya	12.10.2000 at 5 p.m.	216
19	the main crossing road near shidhu kanu chowk	12.10.2000 after 5 p.m.	156
21	gura river near lord shiva temple	13.10.2000 at 9 a.m.	84
22	gura river near the big dam	13.10.2000 after 9 a.m.	147
23	near the nala along the road side	13.10.2000 after 9 a.m.	122
<b>Control in India and in Japan</b>			
24	Ranchi	16.10.2000 at 10 a.m.	129
25	KURRI, JAPAN	14.11.2000 at 3 p.m.	89

## . The result of measurement

### 1. Measurement of air gamma dose by TLD.

Only 9 TLDs were collected though 24 TLDs were sent to India. One TLD(No.24) was arranged at Ranchi as a control in India. And, one TLD(No.25) was left in KURRI (Kyoto University Research Reactor Institute) as a control in Japan.

Total 10 TLDs including 2 control samples were used for the measurement. The result is shown in Table 2.

Table 2 The result of TLD measurement

	Point	mSv/yr	nSv/h
tailing pond			
3	Near tailing pond	8.0	910
5	Near tailing pond	4.1	470
Village			
9	chtikocha near ratan's house	0.9	100
10	chtikocha near ishwar's house	1.2	140
11	mechuwa(dugridh) near prabhat baske's house	2.2	250
12	mechuwa(tuare dugridh) near futani tati's house	1.0	110
15	Mecuwa near mirja shoren's house	1.0	110
Road			
19	Main crossing road near shidhu kanu chowk	1.3	150
Control			
24	Ranchi	2.0	230
25	KURRI, JAPAN	0.4	46

The air gamma dose of No.25 sample was measured as 0.4mSv/y and it is rational value as the natural radiation. Though No.24 TLD was placed in Ranchi as a control in India, the concentration of K-40, uranium series and thorium series in the crust was peculiarly high in Ranchi, so the value of the air gamma-dose was also considerably high as 2mSv/y.

The TLDs arranged in Jadugoda showed higher gamma-dose than that was expected usually. The annual dose limit of the general public for the artificial radiation exposure is 1mSv/y. Though this value is not the regulation value for the natural radiation, this value has been exceeded by only air gamma-dose in most places in Jadugoda.

The levels of the gamma dose around tailing ponds are especially high. And there are high

dose places in the road, either. As I will mention latter, it is thought that tailing was used for the construction material of roads.

## 2. Measurement of radioactive concentration in the soil.

The concentration of radionuclides in the soil was measured after samples arrived at KURRI last year. The result of measurement had already been reported, but the detailed measurement has been carried out using the spare time of measuring instrument afterwards.

The result arranged all those measurement data is reported here.

### A. Pollution unrelated to the uranium mine

First, the unrelated radionuclides to the uranium mine of Jadugoda are shown in Table 3 and Figure 3.

The concentration of the typical radioactive material in the crust is almost same in all samples except the one of Ranchi, in which K-40 and Thorium are abundant. The reason, the sample of Ranchi contains much K-40 and thorium, is probably on the nature of local crust.

And, U.S.A. and Soviet carried out more than 500 atmospheric nuclear tests in 1960's, and the large quantity of fission product polluted the whole earth. However, the temperate regions of the Northern Hemisphere have been polluted densely, because many nuclear test sites are located in that region and mechanism of the atmospheric circulation let the pollution fall there. In case of Cs-137 which is a main fission product, the pollution of Japan which belonged to the temperate regions of the Northern Hemisphere was anticipated to be higher than of India. Present measurement result also shows this tendency. That is to say, Cs-137 concentration in the soil sample of KURRI is several times higher than of Jadugoda. However, the Cs-137 concentration in No.6 sample collected at the first tailing pond is several times higher than of Japan and is one digit higher than of other samples around Jadugoda. It is said that the tailing ponds have also become the nuclear waste dump of the country. And this seemed to be the cause of the abnormal pollution.

Table 3 Concentration of radionuclides unrelated Uranium

		Th-series	K-40	Cs-137
		Bq/kg	Bq/kg	Bq/kg
2	from railway station rakha mines	53	560	
around tailing ponds				
3	near tailing pond	31	540	1.21
4	near tailing pond	23	510	
5	near tailing pond	25	520	
6	tailing pond no. 1	30	350	11.38
7	tailing pond no. 3	84	530	1.90
8	tailing pond no. 2	15	420	
Villages				
9	chtikocha near ratan's house	12	310	0.42
10	chtikocha near ishwar's house	14	360	0.60
11	mechuwa(dugridh) near prabhat baske's house	46	400	0.86
12	mechuwa(tuare dugridh) near futani tati's house	34	490	1.89
13	mechuwa(tuare dugridh) near tati's house	41	590	
14	tilai tand near pulin banra's house	29	360	1.20
20	tilai tand near tapash's house	60	390	
15	mecuwa near mirja shoren's house	42	380	0.87
16	bhatin near gundi hembrom's house	53	620	1.24
Road or River Side				
17	near high school jadugoda	33	680	
18	at the main crossing road near jagdish bastralaya	27	350	
19	at the main crossing road near shidhu kanu chowk	41	570	1.13
21	gura river near lord shiva temple	28	370	0.79
22	gura river near the big dam	39	420	
23	near the nala along the road side	15	480	
control				
24	soil from ranchi	208	1800	
25	KURRI JAPAN	24	430	3.50

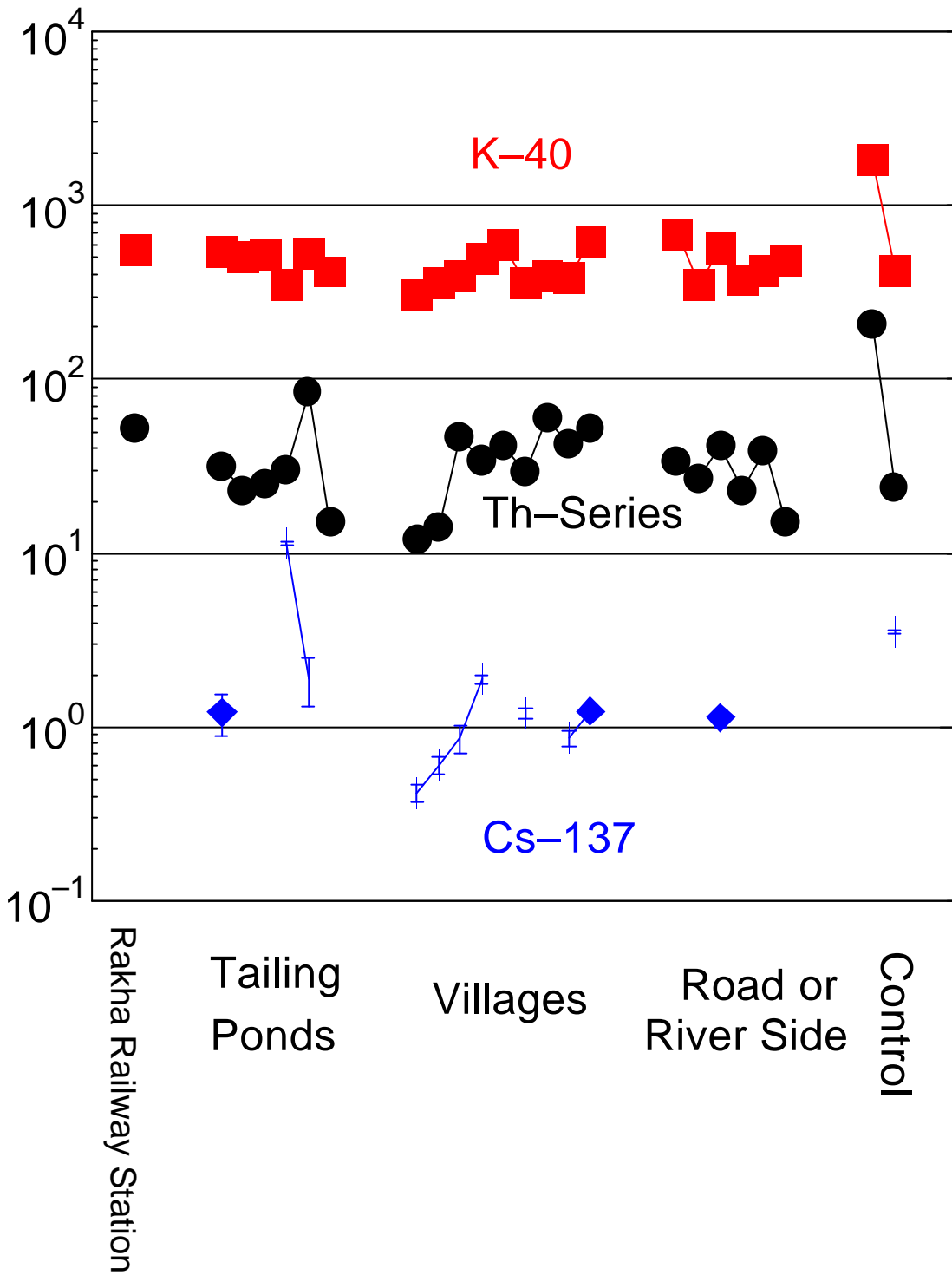


Figure 3 Concentration of radionuclides unrelated to Uranium

## B. The pollution related to the uranium mine

Of course the index of the pollution which related to the uranium mine is uranium. As it is shown in Figure 4, however, uranium itself is radionuclide and its daughter nuclides are also radionuclides. So, they collapse repeatedly one after another. After all, it becomes 14 kinds of radionuclides until it becomes lead (Pb-206).

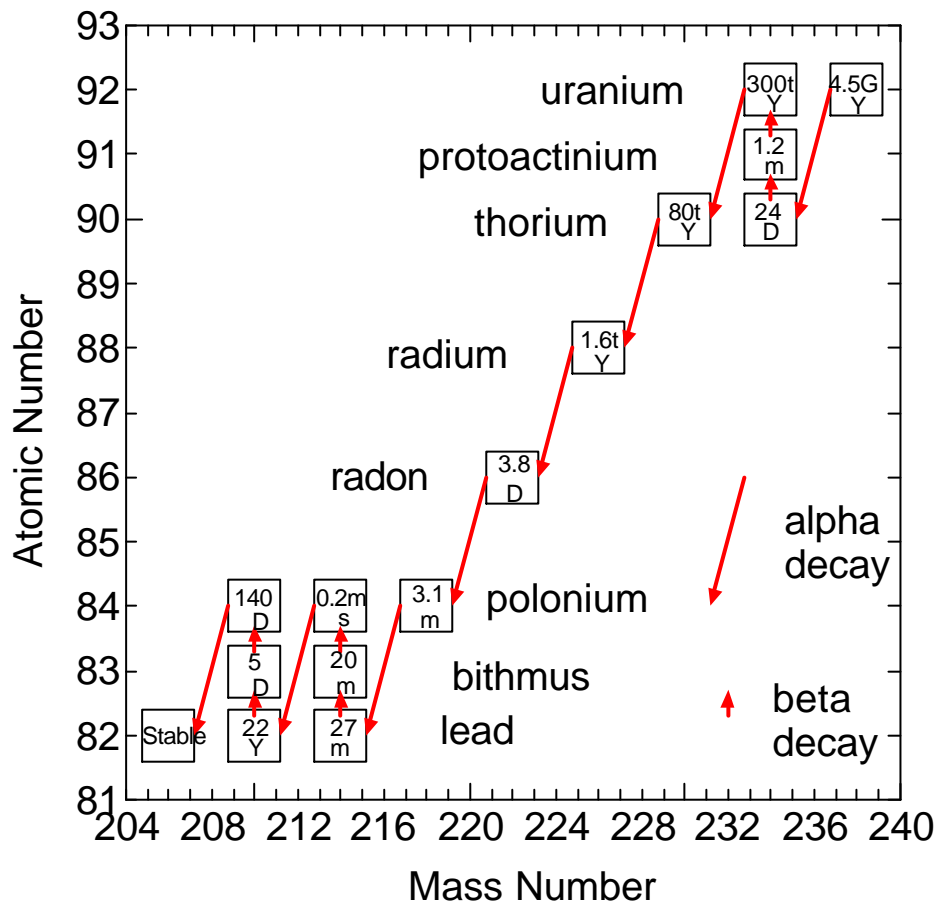


Figure 4 Decay Scheme of Uranium Series

If it does stay in the place where the radionuclide produced one after another, the activity of these 14 kinds of nuclides becomes all the same of uranium.

Such condition is called "radioactive equilibrium". For example, there seems to be in the "radioactive equilibrium", when uranium exists in deep ground.

However, this condition has collapse if uranium ore has once been drawn to the ground surface, because radium dissolves in the water easily and radon which belongs to rare gas escapes to the atmosphere.

And when the uranium is milled, uranium moves to the products and decreases in the waste.

Then, following 3 types radioactivities which are related to uranium were analyzed.



from uranium to the thorium-230, Ra-226 and daughter nuclide under polonium. The result is shown in Table 4 and Figure 5.

The concentration of uranium, radium and daughter nuclide is respectively related in most samples, so they are fundamentally under the condition of "radioactive equilibrium".

Only exception was No.2 sample collected in the Rakha station, in which uranium is remarkably high concentration.

These results are as following.

1. There is not fundamentally large deviation from "radioactive equilibrium" except for NO.2 sample.
2. Only uranium is remarkably high concentration in No.2 sample. This fact shows that the cause of the pollution is uranium milled as a product (yellow cake).
3. The samples around the tailing ponds have high uranium concentration. They reach from 10 to 100 times higher than of KURRI, Japan. And the uranium concentration is comparatively less than of radium and of the daughter nuclides. This fact shows that the tailings caused the pollution.
4. In Ranchi, not only K-40 and thorium also the uranium concentration is high.
5. In the samples of the villages, the uranium concentration varied widely. Especially, samples from mechuwa (tuaredugridh), and a sample from tilaitand have highly polluted.
6. Some samples of the road and the riverside have high uranium concentration too. This shows that the tailings were used for the construction material for the road and bank.

Table 4 Concentration of radionuclides related to Uranium

		U-series	Ra-226	Daughter
		Bq/kg	Bq/kg	Bq/kg
2	from railway station Rakha mines	64000	940	30
around tailing ponds				
3	near tailing pond	1900	3400	2600
4	near tailing pond	1700	1800	1400
5	near tailing pond	1710	2700	1900
6	tailing pond no. 1	840	640	690
7	tailing pond no. 3	6500	3100	7300
8	tailing pond no. 2	540	2700	2000
Villages				
9	chtikocha near ratan's house	20	23	14
10	chtikocha near ishwar's house	34	19	23
11	mechuwa(dugridh) near prabhat baske's house	140	91	65
12	mechuwa(tuare dugridh) near futani tati's house	210	150	130
13	mechuwa(tuare dugridh) near tati's house	350	260	250
14	tilai tand near pulin banra's house	58	28	26
20	tilai tand near tapash's house	130	84	72
15	mecuwa near mirja shoren's house	90	63	52
16	bhatin near gundi hembrom's house	62	34	26
Road or River Side				
17	near high school Jadugoda	67	23	21
18	at the main crossing road near jagdish bastralaya	790	580	640
19	at the main crossing road near shidhu kanu chowk	250	160	190
21	gura river near lord shiva temple	970	2000	1100
22	gura river near the big dam	56	35	21
23	near the nala along the road side	1300	2400	2800
Control				
24	soil from ranchi	210	76	49
25	KURRI, JAPAN	29	19	12

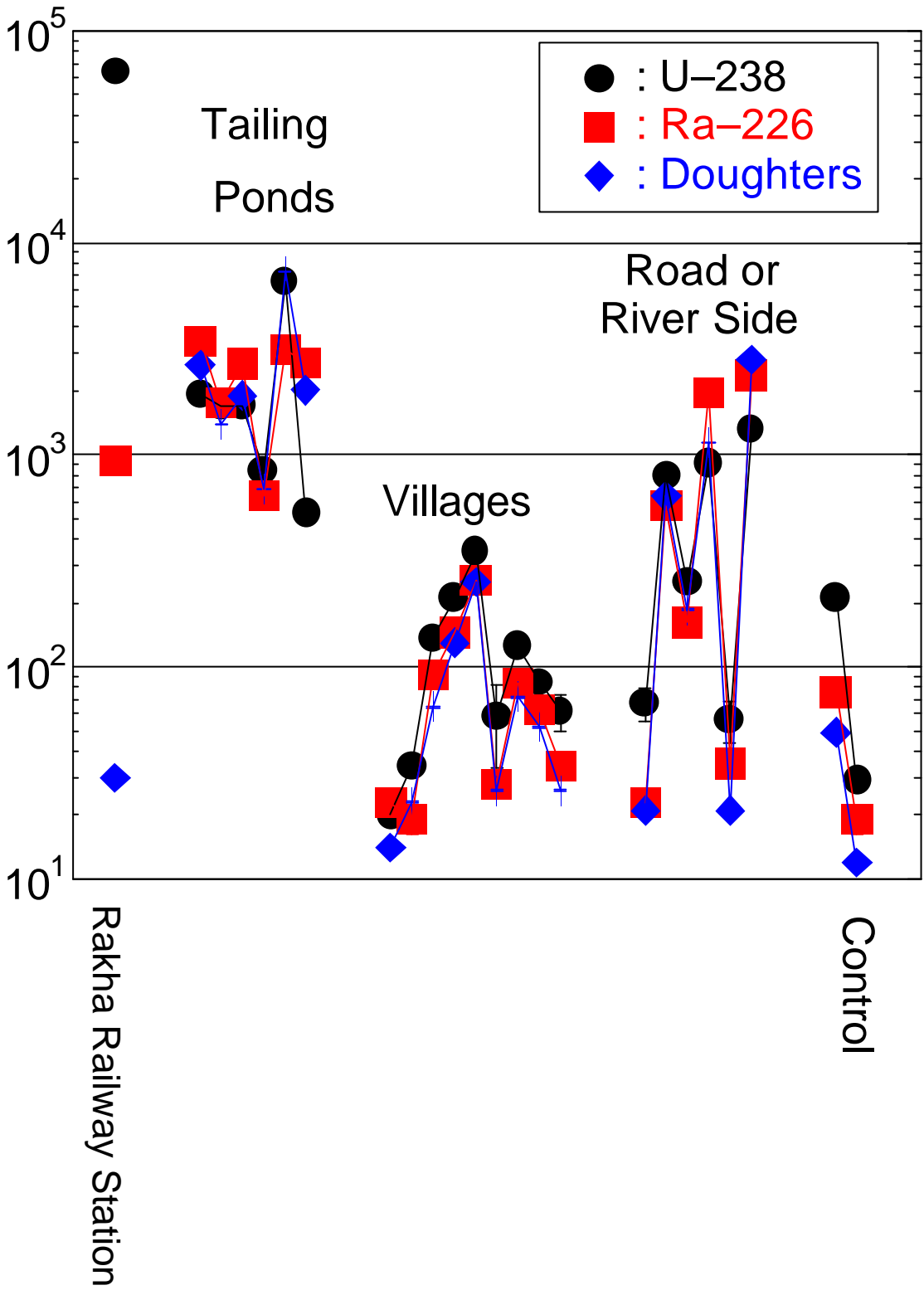


Figure 5 Concentration of radionuclides related to Uranium

## . The summary of result

The very fundamental investigation was done about the radioactive pollution around Jadugoda uranium mine. The results are as following.

1. Pollution from the uranium mine spreads out over Jadugoda.
2. The pollution around the tailing ponds is from 10 to 100 times higher than of the ordinary place.
3. There is a pollution of artificial radionuclide in the tailing ponds. It seems the nuclear waste which is not related to uranium mine was also dumped there.
4. The air gamma dose exceeds 1mSv/y in the village and it reaches 10mSv/y around the tailing ponds.
5. There is the dispersion for the uranium pollution in the village. The level of the high polluted place reaches 10 times than of low polluted.
6. There are places where the uranium concentration is also high in the road and the riverside. It seems the tailings were used for the construction material.
7. In the Rakha station, uranium (yellow cake) which was got by milling caused the pollution.

I thank for Mr. Shriprakash, the director of the video “Buddha weeps in Jadugoda”, Mr.Buruli, the representative of JOAR(Jharkhand Organization Against Radiation), and others peoples who cooperated with the investigation.

In the near future I will measure the radon concentration in the air and make the map of air gamma dose around the tailing ponds.