Jadugoda Tragedy
Price of Superpower Ambitions

The Uranium that fuels India's nuclear weapons and energy program is mined at Jadugoda in Singhbhum district in the state of Jharkhand. The company that does the mining is Uranium Corporation of India Ltd(UCIL) which is a Government of India undertaking under the administrative control of Department of Atomic Energy(DAE). UCIL was established in 1967 and started its operations in 1968 at Jadugoda with Uranium ore mining and a processing plant, each of 1000 metric tonnes per day capacity. UCIL has expanded its activities both in mining and processing plants and presently has:
Underground Mines at Jadugoda, Bhatin, Narwapahar, Turamdih.

Ore processing plant at Jadugoda(mill) for producing Uranium concentrate with a capacity of processing about 2000 metric tonnes of ore.

Plants for Uranium recovery from copper tailings at Mosabeni and Rakha.

The daily production rates at the three mines are said to be 750 tonnes, 150 tonnes and 650 tonnes respectively. The mine at Bhatin is 3 kilometers from Jadugoda while Narwapahar is about 10 kilometers away.

For more than a decade now, there have been a large number of news reports in various magazines and newspapers, detailing various health problems suffered by the people of the area. Mostly these have concerned a large number of deformities in children and various kinds of lung problems. The Bihar state legislative council has issued a document acknowledging the existence of health related problems. Recently, a film, Buddha weeps in Jadugoda has also been made documenting some of the health related problems of the area. UCIL management has persistently denied such reports. Till now there has been no scientific study conducted in the area to determine the extent of such problems. In the absence of such a study, assertions and counter-assertions with no factual basis have had a field day.

Methodology

The purpose of this study is to fill this gap and establish a factual basis for discussion. The methodology used in the study has been tried and tested by many independent groups working in the field of maternal and child health. It required a well-designed questionnaire and a trained team of investigators conversant in the local language. We selected villages for study on the basis of criteria mentioned below. We chose village as the unit. All the households in the selected villages were studied.

Ideally it would have been best if such a study had been done before the start of mining and ore processing operations in the area. In the case one could have just repeated the study now and

compared the results to see what differences if any existed. Unfortunately, doing baseline health studies as part of environmental assessment has yet to become standard practice in Indian development projects. Even today, UCIL is in the process of setting up new mines in Meghalaya but has not bothered to do baseline studies.

Criteria for Selection

In the absence of a base line study for comparison, we have been forced to take the next best option, that of a control area. Choosing a proper control area is always somewhat of a tricky proposition, since one needs to choose a population similar in every respect to the population of the survey area except as regards to the effect of the factor being studied. This is especially difficult in the vicinity of a large □development□ project since the project itself affects the
existing conditions to such a large extent.

The choice of villages near Jadugoda was determined solely by proximity of the village to the tailing ponds. Since we considered the whole village as a unit, all the villages with at least some portion nearest to the tailing ponds were selected. In case of spread out villages, this procedure meant that we have selected households in our survey which do live far away than some other households of other somewhat distant villages. The villages chosen
near Jadugoda were:

1. Mechua
2. Bhatin
3. Tilaitand
4. Rohinibeda

Mechua village though administered as a village by a village panchayat is not considered a village by the census authorities for census purposes. The whole village is considered as a single block of Jadugoda township. Parts of this village are closest to the tailing pond. Some portion of the village, especially the area very close to the bazaar, are indeed urbanized but other portions of the village retain their rural character. Other selected villages are also urbanized to some extent. Only Rohinibeda is not urbanized since most of it lies off the main road in the jungles.
For the controls, we chose two villages:

1. Chandpur
2. Purana Chaibasa

Chandpur village is in the same Potka block as all the four villages in Jadugoda area. Purana Chaibasa is a village just 3 kilometers from Chaibasa town. We selected it in the hope that it would match some of the urban features of the villages in the survey area.

How well do these control villages match the villages of the survey area? Very well if one looks only at the caste(see table 1) and age distribution of the population.

Similarly the age distribution of the two populations matches very well. So do the trends in changes in the sex ratio and other demographic indicators. But it has been difficult to get villages with the same level of economic development as obtains near Jadugoda.

"Others" in table 1 are people who have come from outside and do not belong to any local castes. They are naturally more nearby since they have come looking for jobs and ancillary work which a large development project brings.

	Proximate Villages	Distant Villages
Scheduled Tribes	75.70%	77.00%
Scheduled Castes	3.40%	4.70%
Backward Castes	13.20%	12.70%
Upper Castes	3.70%	4.70%
Others	3.90%	0.90%

Table 1: Caste Composition

Results and Discussion

In this report we will look only at two outstanding questions. Firstly, whether the number of congenital deformities is disproportionately large and whether it has anything to do with the operation of the mines. Similarly, if the diseases of the lung are out of the ordinary and whether they are related to mining operations. Before we get into these two questions let us dispose off some red herrings thrown in the way by the nuclear establishment. Without conducting any kind of scientific study, eminent personalities in the Department of Atomic Energy have said that deformities (if any) seen in Jadugoda were due to poverty, malnutrition and ignorance of sanitary health practices. So, although these eminences are uncertain about the existence of deformities they do know for certain the causes. Before looking into health issues let us first find out if people near Jadugoda are really more poor, malnourished and ignorant as compared to other areas with a similar mix of population.

Benefits of Development

In fact, by making these assertions the nuclear establishment is washing away whatever little credit that is due to themselves. For it can be stated unambiguously that Uranium mining has brought prosperity to Jadugoda.

Despite Purana Chaibasa being just 3 km from Chaibasa town (which incidentally is a much larger town than Jadugoda), the population of the control villages are more agricultural. 44.5% of the head of households work in agriculture or related activities such as animal husbandry. The percentage of such people near Jadugoda is only 27.5%. On the other hand the percentage of head of households having a regular salaried job is 29.1% nearby Jadugoda, but only 15.1% in the controls. Possession of productive items required for a rural agricultural economy like ploughs, bullocks, cows, goats, agricultural and non-agricultural implements, etc, are slightly higher in the control village, though the difference is not statistically significant. There

is a sharp and marked difference in the consumption of non-productive consumer items such as clocks, radios, TV sets, two-wheelers, electric appliances, gas stoves etc. The number of households possessing these items near Jadugoda are usually at least 50% more and they have more of such goods as compared to households in the control areas. For instance, 207 households near Jadugoda possess TV sets whereas this number is only 52 amongst the controls. Since we have surveyed twice as many households nearby, one would expect around a hundred households with TV sets nearby, but 207 shows that the area is definitely more prosperous. This divergence becomes even more pronounced if one looks at higher value items such as refrigerators or two wheelers. Whereas there are 12 households having refrigerators nearby, there is only one such house in the controls. The differences in the two areas for basic electricity services like lighting are not so pronounced. Whereas 42.7% of the households nearby are electrified, their number in the controls is 38.6%. Urbanized modes of lifestyle such as having bathrooms(50 vs 6) or latrines (32 vs 6) are also higher nearby.

The main reason for the increased prosperity is not difficult to find. Unlike the policy in other nuclear establishments where the locals get very few jobs, a large number of people have got regular salaried employment near Jadugoda. As high as 55.3% of the households in the vicinity have at least one member having regular employment with the Uranium Corporation of India Ltd (UCIL) either as miners or as mill workers. At a minimum, this means Rs 5000 per month coming into the house since this is the minimum starting salary. Most earn more. Also regular employment guarantees other benefits such as access to company medical facilities. Of the 920 households in all there are 83 households with more than one person from the house working with UCIL.

Consequently, the picture that the nuclear establishment gives of poor, underfed, ignorant tribals suffering from some undefined conditions unrelated to mining activities is just not true. In fact, although out controls match the survey area quite well in terms of caste and tribal composition of the population, to get an economically matched tribal population is extremely difficult since no other nearby group has 'benefited' to a similar extent due to 'development'.

The sharp differences in economic well being are a problem as far as analysis is concerned. The very essence of a control population is that it mimics the survey population in all other respects but for the effect of the agent being studied. That is just not possible in this case since there is no other area having similar tribal mix with the same level of prosperity in a generally rural setting like Jadugoda.

So the argument in this paper that we present in a mirror image of the argument of the nuclear worthies. We have as a control a population which is demonstrably poorer, has a lower nutritional status and a lower women's educational status but whose general health status is in no way worse and which is significantly better as far as deformities and untoward pregnancy outcomes are considered.

Nutritional Status

During the survey we did a nutritional study of one fifth of the households. These

one fifth were selected by a process of random selection. The questions related to what the family had eaten the day before. We also asked them questions regarding their expenditure on various food items. These questions were used merely to check the consistency of the answers. Table 2 gives a summary of the results.

There is a very large variation in consumption of food. This is expected since the methodology relies on just one day's consumption. Some have feasted and others have fasted, but the averages show that these supposedly “poor tribals” around Jadugoda do eat adequately. In fact the average caloric intake is higher than the national average. It is also higher compared to that in the control villages (2492 calories per day per capita as against 2248).

	Survey Area	Control Area
Carbohydrate	505 g/day	462 g/day
Protein	72 g/day	65 g/day
Fat	20 g/day	15 g/day
Iron	29 mg/day	23 mg/day
Calcium	372 mg/day	286 mg/day
Vitamin C	109 mg/day	79 mg/day
Calorie intake/day	2492	2248

Table 2: Nutritional Status

Educational Status

In this article we are just looking at women's educational status deferring a detailed full analysis to a later date. The women considered in the table are in the reproductive age group between 15 years and 45 years of age. Table 3 gives a summary:

While 59.3% illiteracy is a shame it is definitely much better than 67% of the controls. As can be seen from table 3 this seven percent difference is distributed amongst the class-5-and-above categories. Numerous studies have shown that higher levels of women's education result in better hygiene and health status in the household.

	Illiterate	Up to class 5	Class 5 to class 8	Class 8 to class 12	More than class 12
Proximate Villages	59.30%	11.50%	7.50%	19.00%	2.60%
Distant Villages	67.00%	10.40%	4.10%	16.30%	2.10%

Table 3: Educational Status

On Deformity

A quick glance at table 4 tells us that the number of houses surveyed near Jadugoda was double that of houses surveyed in the controls. This is also reflected in the population, which just shows that the household size in both areas is similar. Thus, one expects the number of deformities to be twice near Jadugoda as compared to the controls. However, as one can see, the numbers involved are twice as large. The probability of this happening just by chance is less than one in seven hundred.

Data collection for the survey was done in September 2000 whereas mining in Jadugoda started in mid sixties. People older than 35 years of age were born before the commencement of mining. Among them we see that there are only three people each in both the areas with deformities. This may seem a surprise since we expect to see twice the number near Jadugoda. However, the numbers involved are small and a single case this way or that can change the whole picture.

But when we look at people born after the start of mining operations, we find that there is a statistically significant rise in congenitally deformed amongst them. If we take the multiple deformities into account then the probability of such a huge rise in deformities having occurred just by chance is about one in hundred thousand. One can be fairly certain that the increased level of deformities in children is a real effect and not some statistical anomaly.

Additional support for this is gained by looking at table 5. This table shows that deformed children are still being born in Jadugoda and its environs. The huge increase in deformities is not due to some past accident whose effect will slowly vanish. It is a continuing disaster.

The total number of pregnancies was 409. Of these there were 265 pregnancies including a pair of twins near Jadugoda than in the controls. There were four cases in stillbirth (one with deformity) near Jadugoda as compared to two in the controls. There were 15 cases of congenital deformity amongst 266 children born near Jadugoda while there were just two cases amongst 144 born in the control area. Of the 14 live births with deformity near Jadugoda eight died and only six survived. One of the children with deformity in the controlled area also survived. The total number of live births in Jadugoda were therefore 262, while the number in the controls was 142. Of these 262, nine had died within a year whereas six had died in the far area. Of the nine who died near Jadugoda, six had died within a few hours of birth, and another had survived for nine months. Both of them also had deformities. One child survived for a year before death (of diarrhoea) and had no deformities. In the control villages, two were premature babies who died within a few hours after birth; three others had died a week after birth of diarrhoea and one had survived for a month.

There are two major causes of death of infants within a few hours of birth. Either there are obstetric problems during delivery or the fetus itself is defective. The chances of obstetric problems during delivery being the cause of the higher number of one day deaths in Jadugoda are minimal because

being prosperous it has attracted better medical care. Also since a lot of household heads are company employees, they are entitled to and avail company medical facilities. These facilities include reference to well equipped hospitals at Jamshedpur and an ambulance service if need be in an emergency.

An examination of the causes of death amongst children shows wide divergence in the two areas. Of the nine deaths of children within a year of birth, eight had congenital deformities and consequently, their chances of survival were anyway rather slim. On the other hand in the controls of the six deaths, only one can be attributed to deformity whereas five were due to environmental reasons.

	Proximate Villages	Distant Villages
Number of Pregnancies	265	144
Number of Births	266	144
Number of Stillbirths	4	2
Number of live born children who died later	9	6
Number of stillborn children with deformities	1	0
Number of live born children with deformities	14	1
Number of deformed children who died	8	1
One day deaths	6	2
Deaths among children with no deformities	1	5

Table 5: Untoward Pregnancy Outcomes in Last Two Years

Chronic Lung Disease

Fully 55.3% of the households in Jadugoda have at least one member working as a regular employee of UCIL. The average family size of such households is larger than others and so more than sixty percent of the people living in villages near Jadugoda are covered by the employees medical insurance schemes of the company. It is important to keep this fact in mind when looking at the data presented below.

Studies all over the world of Uranium miners have shown that they have higher incidence of diseases like silicosis and lung cancer. This fact has been known for almost two hundred years since Uranium mining started in Czechoslovakia. Even when a diagnosis of lung cancer or silicosis was unknown, people knew that Uranium miners were prone to “mountain sickness” which cruelly cut short their lives. The high incidence of chronic lung problems amongst Uranium miners is not surprising. They work in an environment which is full of dust

caused by blasting the rock.

There is surprisingly not a single case of any such work related disease amongst Uranium miners and mill workers in any of the people we examined near Jadugoda. What we have instead is an anomalously high incidence of TB.

Let us go step by step. The total population surveyed near Jadugoda was 5150 while that in the controls was just a little less than half of that 2492. In the controls we found 23 cases of TB (nine per thousand). On this basis one would expect 46 cases of TB near Jadugoda. Hence, finding 84 people (16 per thousand) was already on the higher side. Not all of these cases were currently ill. 57 cases near Jadugoda and 15 cases in the controls said that they were currently suffering and taking treatment for the disease. Of these 44 cases near Jadugoda and just six cases in the controls said that not only were they currently ill but that they had been taking treatment for two years or more but without any improvement.

TB as is well known is a very persistent disease. Patients immediately feel better on taking prescribed drugs and a good number of them are prone to discontinue treatment at some intermediate stage, which leads to recurrence of symptoms of the disease some time later. So for the purpose of simplicity we will do our analysis by including all who have been diagnosed as suffering from the disease. However, we should emphasize here that the conclusions of the analysis do not rest on this choice. We can equally well choose to do the analysis on currently ill patients only or take the even smaller subset of persistently and currently ill and it will make no difference to the conclusions.

Let us divide the 5150 people living near Jadugoda into two groups. People who come in contact with Uranium directly such as miners, mill workers, casual laborers who load and unload drums of yellow cake on to trains for transport to the Nuclear Fuel Complex at Hyderabad, or the truck drivers who bring Uranium ore from the mines at Narwapahar and Bhatin to Jadugoda and take the tailings slurry back for backfilling the mine etc, and others who do not come into direct contact. These include the family members of the first groups along with others such as shop keepers and farmers who for some reason or the other have never caught the Uranium frenzy. The first group, that of the Uranium workers consists of 603 individuals whereas the other group of Uranium non-workers has 4547 people in it. Of the 84 who complained of 'TB' most of whom thanks to the good coverage provided by the employee's insurance scheme have medical records to prove their claims, 49 belong to the first group of workers and 35 belong to the second group of non-workers. These numbers are summarized in table 6.

The numbers in parenthesis are incidence per thousand. As we can see the incidence of TB amongst Uranium non-workers is lower than that amongst the population in the distant villages. This is to be expected since there is higher level of prosperity in the proximate villages. They eat better, and have roomier houses. Unfortunately, the price for their prosperity is paid for by the greater than ten times higher rate amongst the bread-winners. The chances of this anomalously high rate amongst Uranium workers being just an inadvertent statistical construct are less than one in a hundred million.

The simplest explanation for the large number of 'TB' cases amongst the Uranium workers is that not all of them are TB, but some or those mysteriously missing occupational lung diseases like silicosis and lung cancer that we talked about earlier and which have been seen amongst Uranium miners all over the world. Because of the fine medical coverage provided by UCIL, the blame for this mis-diagnosis can be laid squarely on the shoulders of the UCIL doctors. They are either totally incompetent or worse still, doing this deluberately in order to save UCIL management from compensation due to occupational diseases.

The consequences of this mis-diagnosis are not benign. Being diagnosed with TB, patients continue to take TB treatment for long periods with no relief. This is also reflected in the information about deaths during the last two years that we collected.

	Uranium Workers	Uranium Workers with 'TB'	Uranium Non-workers	Uranium Non-workers with 'TB'
Proximate Villages	603	49(81.3/1000)	4547	35(7.7/1000)
Distant Villages	13	0(0/1000)	2479	23(9.3/1000)

Table 6: Phenomenal Rise in 'TB' Amongst Uranium Workers

Dead Men Do Tell Tales

A total number of 148 persons died in the two years previous to the survey in both the areas combined. 98 nearby Jadugoda as compared to 50 in the controls. So far so good. This is to be expected since we surveyed twice as many houses near Jadugoda. But a detailed look at the pattern of death is very revealing.

Let us divide the group into two. Children who have died before the age of twenty and adults who have died after reaching that age. Amongst children we find that 20 died near Jadugoda as compared to 13 in the controls. Of these twenty, eight or fully 40 percent died due to deformity (most during the first few hours of life itself) whereas amongst the 13 who died in the controls, only one died due to deformity. We have written about this earlier, but one needs to look at just one aspect-the male-female ratio. Of the thirteen who died in the controls, there were six boys and seven girls, but of the twenty who died nearby Jadugoda, there were seven girls but thirteen boys. The preferential difference for boys over girls is accounted for by looking at those who died due to deformity. Amongst those eight are seven boys and just one girl. Other deformity studies all over the world have shown that boys are more likely to be born with deformity than girls and the chances of survival of these babies is any way slim. The 'weaker' sex is stronger where it counts.

Amongst adults the total number of deaths in both areas is 115. Of these 78 have taken place near Jadugoda, while 37 have occurred in the controls. Out of the 78

near Jadugoda, 53 have been males and only 25 females, while in the controls there were 22 males to 15 females. Why does death prefer men over women so strongly near Jadugoda?

The answer to this riddle is provided by looking into deaths due to 'TB' or to give it to correct name chronic lung problems. In the controls the number of such deaths amongst men are 4 out of 22 (18.2%) while it is 2 out of 15 (13.3%) in women. Near Jadugoda death due to lung diseases amongst women is comparable, 3 out of 25 (12%) but amongst men it is a whopping 22 out of 53 (41.5%).

TB today is a curable disease. Reluctance of some patients to continue the long treatment, does result in persistent recurrence and ultimately drug resistance and death. The numbers out here are too stark and show something quite abnormal.

No discussion of radiation effects can be complete without a mention of cancer. The radiation community considers an increase in cancer as the only effect of radiation exposure. Mr. S.K. Malhotra, Head, Publicity Division, Department of Atomic Energy, writes in a letter to the editor of Hindu that “It may be worthwhile to note that while the Indian Council of Medical Research (ICMR) has estimated the national average incidence of cancer to be 74 per one lakh population, in Jadugoda the incidence is only 22.”

One is not sure in this quotation whether ICMR has estimated only the first portion (the national average of 74 per one lakh population) or also the second part regarding Jadugoda. I guess not. During the survey we found that there were six deaths due to cancer in the previous two years. Five of them near Jadugoda and one in the controls. Amongst the living, six households reported cancer cases, all of them near Jadugoda. However, when our team of doctors visited the houses, they could confirm only four cases. These had medical records from the hospital belonging to Tatas at Jamshedpur. The other two were not available at the time of the visit. Even if we discount these and take only the four confirmed cases it works out to an average of 80 per one lakh of population-a little higher than the ICMR's national average. So what about this 22 per one lakh that Mr. Malhotra so confidently claims. Perhaps it was the rate in Jadugoda before Uranium crazies got going.

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Stray Thoughts on Survey Design and Methodology

Surveys can be a very powerful
tools in establishing facts. However they need to be conducted properly and purposefully. There are just too many steps than can go wrong. A badly done survey is not only a waste of tremendous time, effort and money but it can also mean inconclusive and irreproducible results: a long-term loss of credibility.

Some real life examples of what can go wrong:

A group of Indian doctors in India was studying Lathyrism, a wasting conditions associated with intake of certain types of lentils. They consulted an epidemiologist, a survey questionnaire form was made, and surveying teams were trained in completing these forms. Since the prevalence area of the disease was large and the number of surveying teams was limited, villages were randomly selected and assigned to each team. One of the teams had drawn a village in a very remote area. The roads were terrible, gasoline stations were few, and they had flat tires galore. They finally had to walk the last few miles to reach the village. On reaching their destination after such a heroic effort, they were astonished to learn that there were no cases of Lathyrism in the village. However there were quite a few in the adjacent village. The team decided to go to the next village and do the survey there. After all, the process of drawing village names could just as easily have come up with village number two instead of village number one. Unfortunately their decision was precisely the wrong thing to do since it violated the randomization process itself, which was the basis of the whole survey.

Another group was doing a survey of maternal and child health in a polluted area. The survey forms contained questions regarding family related information that anybody in the family could have answered, like assets, and some questions that had to be asked of the woman alone, like her pregnancy history. Normally, names and ages of family members should have formed part of the family information questions, but had been included only in the woman's part. Data collection was completed and entered into computers. Data analysis had already started when the problem of the unfortunate questionnaire design became apparent. Since questions regarding the age and sex of children formed part of the woman's questionnaire, they had not been collected from a number of houses because the woman had not been available at the times of the investigators' visit. As a result, even simple questions like the total population or its sex and age distribution became unanswerable.
Another group decided to use voter lists and municipality house numbering system as part of their survey. They soon found that large numbers of people had been arbitrarily left out of these lists.

The above examples illustrate just some of the various ways in which things can go wrong, rendering a survey meaningless. Thus it is important to adhere strictly to procedure. Surveys can be demarcated into four phases:

1. Design Phase
2. Data collection phase
3. Analysis
4. Dissemination of results

The objective of the survey needs to be well-defined and this is best done during design phase. The temptation to ask many questions on various topics is strong and needs to be stoutly resisted because both the investigator as well as the respondent get tired filling out long questionnaires. Tired and bored investigators skip over questions whose answers seem 'obvious'. However, all the questions directly relates to the objective must be asked and they usually form a large enough set.

It is easy to miss asking questions that can be of crucial importance. For instance, one important problem with our Rawatbhata survey (which was the first we had ever done) was that we only asked whether anybody from the household was employed in the facility at the time of the survey. This gave us a list of people who were currently employed but no information regarding past employment. Thus, we were not able to make any statement regarding whether length of employment in the plant and type of work were in any way related to the high incidence of congenital deformities observed amongst the children of the area.

Before designing a survey plan it is important to define criteria for selection. Once the criteria are set, all entities satisfying the criteria become part of the survey universe. For instance, the criteria may be all villages within a particular distance and direction from a polluting factory. But then all the villages in that direction and within that distance have to be included in the survey; one cannot exclude a particular village because of inconvenience or because one knows that there are no "cases" there. Similarly one cannot exclude some village because it is too large and beyond capacities of the survey team. In such a case one needs to rethink the criterion used for making the selection in the first place or do random sampling. We chose to survey all households rather than do random sampling.

The more one can refine the objectives of a survey the better. This results in better survey form design and can save time and hassle later. The time one has at one's disposal in the field is severely limited. One cannot spend it writing repeatedly similar information. As the survey form is being developed, the designer should ascertain all the types of responses likely to be answered for each question and then number and pre-code them in the survey form itself. Then in the field the surveyor simply chooses the given answer from the list and notes its number. If one has the time it is a good idea to do a sample pre-survey so that some of the difficulties become apparent and can be corrected before a major expenditure of effort.

Before the data collection stage, various teams must be trained and tasks assigned to them. These tasks are mainly of three types:

1. Numbering: Before the filling of survey forms can begin, one needs to number each and every house that forms part of the survey universe. Even if one decided to do random sampling, this step has to be done so that every house has an equal chance of being selected.
2. Filling of the survey questionnaires by specially trained teams.
3. Checking of filled schedules by experienced persons. This needs to be done as quickly as possible so that any errors can be corrected while the team is still in the field. Revisiting the field, as for corrections later is a great pain, but has to be done in case vital information has been left out the first time.

There are a large number of good computer programs for analysis. The one which we like best is EPI-INFO. This is an extremely user-friendly program specifically designed by the World Health Organization and the U.S. Centers for Disease Control and Prevention for health surveys especially to track the spread of AIDS in Africa. Besides

having some very good analytical features, it is free. However, before analysis can be conducted, data needs to be entered into computers, and before that, all the forms need to be checked to ensure that nothing has been missed and that they are in fact computer ready. It is at this stage that one appreciates the time spent in designing the survey form since, with a well-designed form, data entry becomes simplified.

The task of dissemination of results is usually done through publication in scientific journals. But if science has to be the basis of democratic action, then this is the most important part of the survey. The information that forms the basis of the survey is community information and it must strengthen the community. In places where most people in the community are illiterate, the dissemination of results must be as non-literary as possible.

It depends on how you look
Despatches from the Radiation Front

There has been a good deal of acrimonious exchanges regarding radiation levels around Jadugoda. The following table is from a report brought by the UCIL management and prepared by Dr. O. Jha, Scientific Officer/E, BARC of Health Physics Unit, Jadugoda (the 'independent radiation monitor'). One day while we were doing data collection during the survey Dr. Jha himself arrived and complained that we had been publicizing falsehood with regard to radiation readings in the neighborhood. He suggested that perhaps the instrument we were carrying was in need of calibration. The upshot of the discussion was that I agreed to accompany him and take joint readings. As it happened his instrument gave slightly higher readings than mine. Not a big surprise since his has been in regular use for long and was likely to have been a bit contaminated. So the question of calibration was settled. We took readings at many places and were in complete agreement. Mine were consistently a bit less than his.

Just outside his office, was a pile of rocks. The readings there were three times higher than the ones we had been taking. I asked him why he did not take readings near this pile or many other similar piles spread all over Jadugoda. His answer was that this was mine over-burden rock and readings near such piles were bound to be higher.

Therein lies the crux of the controversy. The averages one calculates depend upon where all the readings have been taken. Since radiation levels vary greatly within short distances and times, it is easy to get widely varying numbers. So the chart presented by Dr. Jha is not erroneous. It just gives averages based on a judicious selection of sites by a functionary whose job is to provide a clean chit to UCIL authorities. It is just one side of the picture. What really matters to people's health is how much time they spend in these various locations.

Location	Direction from Tailing Pond	Radiation dose rate (μGy/hr)
Chatikocha	0.1 Km SW	0.03 – 0.09
Dungridih	0.2 Km NE	0.20 – 0.35
Bhatin	0.8 Km NW	0.10 – 0.34

Market	1.1 Km E	0.10 – 0.20
Colony	1.4 Km E	0.07 - 0.20
Tilaitand	1.1 Km S	0.09 - 0.15
Sosoghutu	1.4 Km NW	0.12 - 0.24
Sitadanga	3.5 Km	0.07 - 0.20

Table 7: Radiation dosage of various locations near the tailing pond

A word about units

All experts like to keep the laity in their place by using obscure and confusing terminology. Think of doctors talking of gastritis when all they mean in pain in the stomach, or of lawyers whose small print is legendary. We physicists get out kicks by using multiple units for measurement.

One Gray(Gy) of Dr. Jha's chart is equal to 100 Rads(R) in ours. He puts a μ(micro) in front meaning a millionth of, while I have put an m(milli) meaning a thousandth of in front of mine. So when he says 0.03 μGy/hr and I say 0.003 mR/hr we mean exactly the same thing. The hr stands for hour and that luckily remains the same for both of us.

However doses are sometimes expressed not per hour but per year. /yr instead of /hr. For converting the /hr dose to /yr dose one needs to remember that there are 24 hours in a day and there are 365 days in a year. So one needs to multiply the /hr dose with 8760 to get the per year dose. Busy people tend to forget that there are 24 hours in a day. A delegation from Bihar legislative council which had gone to Jadugoda to investigate, multiplied the per hour dose given by their instrument with 360. Extremely busy people forget that there are 365 days in a year. Consequently, the radiation doses they published are wrong by a huge amount.

The following is an exchange of letters with my friend Dr. M.V. Ramana of Princeton University. Since it gives the flavor of immediacy and also reminds me of the long time it has taken me to write this report, I have taken the liberty of keeping it as it is in the letter format. Readers of this article will excuse the unconventionality.

Readers will also hopefully excuse the extensive use of the first person singular in what follows. Readers of previous issues of Anumukti have upbraided me for this failing and have asked that 'I' be identified. Here, it means me, Suren.

Date: Firday, July 07, 2000 11:04 PM

We just returned from Jadugoda. I have just received the gift of a Geiger counter and this has proved to be of great value. Till now I had been skeptical of taking radiation measurements but no more.

I have yet to look at all my readings and come to a definite conclusion but some interesting points can be made straight away. First and formeost the range of background radiation is fairly low. Most readings are in the range of 0.005 to

0.017mR/hour. This range seems to extend even as far away as Tatanagar. Near the tailing pond No 3 which is right next to Chatikocha village the readings are about double of this. Somewhere between 0.025 to 0.040 mR/hour. However, this is fairly close to the tailing pond, so the claim of the establishment that radiation does fall back to the background within 20 meters of the pond does seem OK. One can quibble if it is 20 meters or if it is 40 meters and that may vary in different directions and seasons but by and large that claim does seem to hold.

While I was taking readings a guard came but I just ignored him and continued to take the readings as if I was an official of the department and if he wondered about the strange officer who wore pyjama kurta, that was his problem.

There are three tailing ponds in the place quite close to each other. These are huge affairs. During the last two years they have all acquired large stone wall and some of them also fencing. Pond no. 3 was being filled as I took the readings about 7 meters above the discharge pipe. This pond is fairly close to a village but recently there is a fencing put up and a guard posted.

However, when I went to tailing pond no. 1, it was a different story. This was completely dry with grass growing on top. The readings on the surface of the pond were anywhere from 0.1 to 0.35 mR/hour. I approached this pond from a football field next to which was a hill. There were two different roads going up the hill and we went up both. On both the roads, trucks had gone and dumped black colored rocks. These I learnt later had been used to close vents from the mine but here again the readings were anywhere from 0.07 to 0.32 mR/hour. Putting a piece of paper to cut out the alpha part of the radiation reduced the readings by a factor of one tenth. So an average measurement of 0.330 mR/hr without paper would give readings around 0.3 mR/hr with paper in front. So, contrary to claims, there is an alpha component in what is vented. There was an open vent from which air was being vented and the readings there too were of the same order (0.32). I was told by the people who took me there that cows felt very refreshed coming up there since the air was cool and a welcome relief from the oppressive heat. It was a practice that the shepherds too were prone to indulge in.

The highest reading that I was able to record was 0.604 mR/hr and this was on the other side if this hill at a distance of 100 meters from the tailing pond where some garbage had been dumped which included stuff like a regulation shirt and gloves. Although this area is not cordoned off from the public I did not get the impression that many people go there regularly since it is not on the way to anything. The next day I took readings at a large number of places where the mined rocks have been used for filling purposes. This has been done also for road construction and some people have taken these rocks and used them as foundation for their houses. Readings right next to the stone varied from 0.06 mR/hr to 0.12 mr/hr whereas the houses recorded 0.025 mR/hr to 0.035 mR/hr near the ground level. This I believe is probably because of the mud and cow dung used as a plaster.

On the road near the main chowk where most people gather during the day the readings were 0.034 mR/hr to 0038 mR/hr at my hip level an from 0.038 mR/hr to 0.044 mR/hr at the ground level. There was a lot of grey colored dust on the road which is due to the large number of trucks carrying this rock which ply to and fro.

I also took a reading from an empty washed truck and the readings there were from 0.025 to 0.028 mR/hr near the driver's seat. The Uranium Corporation of India Ltd (UCIL) has a colony in front of which there has been a good deal of rock filling and readings just outside their campus were 0.036 mR/hr to 0.045 mR/hr at the hip level and 0.08 mR/hr to 0.102 mR/hr at the ground level.

There are other copper mines some distance away and we also visited them. They don't have the elaborate walls around the tailing ponds which are just located outside the Uranium recovery plants. There were quite a few cows sitting on the pond and two people were dipping some utensil into the discharge water. From a distance I thought they were fishing but later learnt that that they were gold prospecting. The readings here were 0.055 mR/hr to 0.065 mR/hr at the hip level and 0.102 mR/hr to 0.114 mR/hr at the ground level. We traveled up to Musabeni on the Suvarnalekha river where we found that tailings from the copper mine were being directly discharged into the river and the readings here too were similar. The distance between Jadugoda and Musabeni would be well over 25 kms.

As can be seen from all this, the pollution is not just due to tailing pond No. 3 at Jadugoda which after all the publicity of the last year seems much safer than most other places in a wide area. We also took readings at some villages nearby where there is no mining and where there has been no landfill using these Uranium containing rocks. These were 0.011 mR/hr to 0.013 mR/hr outside and little higher 0.017-0.019 mR/hr near the walls of the houses. I also took some readings of of iron ore and coal being taken in trucks near Nowmandi which is about 100 kms from Jadugoda. These were 0.005 to 0.012 mR/hr.

Date: Thursday, August 10, 2000

Sanghamitra has just returned from Jadugoda. A more useful trip than I had expected since lot of people showed a great deal of enthusiasm for the survey. Also the public programme had a very large attendance from the children (1500). Sanghamitra also took a number of readings in various villages which confirm what I had taken in the earlier trip. The biggest problem is the mine overburden rocks which have been spread all over. When the government gives a contract for road building, UCIL tells the contractors that it can have all this wonderful rock for free or rather just for the cost of trucking it away. Since anyway the government road building contract does include payment for materials (stones) the road contractors make huge profits with consequent cuts to everyone important in the hierarchy. Wherever the stone has been spread, the radiation levels are around three times the normal background at hip level and about five to six times the background at the ground level. Since the stone is readily available a large number of people have also used it as foundations in their houses. Even the school buiding has been constructed with this stone.

The most glaring reading is in a ward of the Jadugoda township called Ichida. Here the hip level readings on the pucca road are 0.081 mR/hr to 0.115 mR/hr and the ground level readings are from 0.127 mR/hr to 0.335 mR/hr. There are houses on both sides of this road and the readings on the veranda of the houses are in the range 0.03 mR/hr to 0.035 mR/hr whereas the readings in the inner rooms are 0.013 mR/hr to 0.016 mR/hr.

Luckily as usually happens the money ran out and the road is only half pucca and themselvesrest is kutcha. The readings from the kutcha road at ground level are between 0.018 mR/hr and 0.024 mR/hr.

A few days back we gad been invited to a public talk at Vyara which is a small taluka town 15 km from here (Vedchhi, Gujarat). The talk was by two guys from Kakrapar nuclear power plant. It was the usual incomprehensible and boring gibberish till Sanghamitra enlivened it by showing a map of the area and a copy from their official emergency preparedness manual which showed that the plan calls for the whole of Vyara (population 40000) to be shifted in case of evacuation to Dua's schools to Bardoli. Even if they pack them like the British were supposed to have been in the black hole of Calcutta, I think more than half would be left outside. After this disclosure of course there was bedlam and the meeting broke up acrimoniously. But before that these guys had made a significant disclosure that the background radiation of Kakrapar is 231 mR/year. I challenged the guys and found another document which gave the average for Gujarat as 49 mR/year. My own measurements at Vedchhi and at Vyara seem to be in the region of 70 to 100 mR/year. I need to go one of these days to the place and make measurements to see if these figures are OK. I would be very surprised, indeed shocked if they have already polluted Kakrapar to such an extent.

Dr M.V. Ramana too is a physicist and uses a yet another set of units in what follows. For all practical purposes of making sense of making sense of this article his rem and my R are equivalent and so is Dr. Jha's Gy and Dr. Ramana's Sv.

Date: Thursday, August 10, 2000

That is very interesting. So it seems that a person living in a house in the Jadugoda area with a foundation made of mined stone would have an annual radiation dose of about 150-200 mrem/year = 1.5 – 2 mSv/year. Even without including the internal dose, this is already greater than the allowed 1 mSv/year and can be used as the basis of at least violations of safety standards of not health effects. Are these total (alpha+beta+gamma) doses?

As for background radiation, one paper I have from the Indian Journal of Power and River Valley Development, Oct-Nov 94, by U.C. Mishra and S. Krishnamony claims that the average per capita dose to the Indian population are:
Natural radiation:
external = 0.73 mSv/yr;
internal = 1.7 mSv/yr.
Just FYI, their estimates of others are:
medical = 0.048 mSv/yr
nuclear fuel cycle = 0.12 mSv/yr.
nuclear tests = 5.8 mSv/yr.
Toral = 2.5 mSv (*does not add up, something is wrong*)

This may also explain why the Karparkar fellows are claiming 231 mrem as the background whereas you are finding 70-100 mrem. They must be including

the internal doses as “background”.

Lessons Not Learned

The mine may not be properly ventilated. Some of the readings measured by a Greenpeace team suggest that the mine air contains very high amounts of radon.

Mine overburden rock has been spread all over the place. This material being the responsibility of the mine is available very cheaply and UCIL has been selling it to road and other building contractors. Thus most roads in the area have been constructed using these rocks. A lot of people have also used this rock in foundations of their houses as well as in concreting. Luckily very few houses till now have been made of concrete but this trend is increasing with urbanization. Levels of radon in houses built of concrete using mine overburden rock are in some cases as high as 1000 Bq/Cubic Meter.

The tailing ponds of the mine are not properly kept. They are not covered by water all the year and so during the summer season huge swirls of dust rise from the ponds and carry the dust to villages nearby. There has been no programme of public education regarding these ponds and people earlier used to walk on the ponds since that was a shortcut to some villages. However at least near Jadugoda this practice has now stopped since there has been a campaign against UCIL amongst the people. But there are other tailing ponds of copper mines from where Uranium is also extracted where no precautions are still being observed and I have seen cows grazing and people trying to collect gold from the tailings. In another mine in Musabeni about 25 km from Jadugoda, the tailings are dumped directly into the Suvarnalekha river which is a major river in the area.

The tailing ponds are used as a low level radioactive waste dump. Thus fuel fabrication waste is brought back from Hyderabad along with medial radiocative waste from all over the country and is dumped in the tailing ponds.

Because all the crushing and chemical treatment to extract yellow cake is done at the Jadugoda mill, the ore is brought in open trucks from Narwapahar and Bhatin mines to Jadugoda. Also some of the slag from the mill is taken back to the mines for filling purposes. Quite often this rock and dust from the trucks falls on the road which are always covered with dust and give readings as high as five times the background. Thus walking on the road becomes hazardous.

There are no laundry facilities at the mines. Workers wear the same clothes for six days. On Saturdays they are given the clothes to take home for washing. This washing is done in local ponds in the villages where people bathe, wash dishes and utensils etc. The clothes after six days of use are extremely dirty and have accumulated a fair amount of mine dust. All this dust becomes part of the sediment in the ponds.

The biggest problem of all is the totally callous attitude of the mine authorities towards worker safety. Although I have no knowledge of what goes inside the mine,

this attitude can be seen quite easily in overground operations. Like the radioactive waste that is brought back to Jadugoda from Fuel Fabrication Unit at Hyderabad comes in ordinary rail wagons in drums quite a few of which are leaking. The workers who handle this at the Rakha Mines Railway Station (the nearest station to Jadugoda) do so with bare hands and feet. Their supervisors look on and are not bothered by these gross violations of their own rules. It is only when someone photographs such activity that the authorities become concerned about the company's image. UCIL also does not bother to measure the dosages received by temporary workers. Although it does measure dosages received by its permanent workers this too is not done regularly. Most workers reported that medical examinations had been conducted only once in a few years. But in all such cases, the company had not bothered to inform the workers themselves of the findings.

Why do I say that lessons have not been learnt? Because the nuclear establishment is in the process of opening new mines in Nalgonda district of Andhra Pradesh. Here they intend to do the same kind of extensive transport of ore and slurry over a distance of 16 km between the mill and the mine. Do open-cast mining with extensive blasting next to a natural tiger reserve. Create 7.5 million tons of waste to get just 1250 tons of Uranium ore. And so on and on. But this story is for another issue of Anumukti.