The Health and Environmental Impact of Coal Mining in Chhattisgarh

A SUMMARY

NOVEMBER 2017

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A study to assess the Health Impacts on Populations living in close proximity of Coal Mines and Thermal Power Plants in Raigarh district, Chhattisgarh.

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November 2017

This report is dedicated to people of Sarasmal, Kosampali, Dongamahua, Libra, Kodkel and surrounding villages who have lost their land and livelihood due to close by coalmines and power plants – their health and mind have been affected badly due to the pollution and the loss of economy.

The study has been conducted jointly by People First Collective, India and Adivasi Dalit Mazdoor Sangathan, a Raigarh-based social organisation.

Cover photo: Women of Kosampali village in a meeting. Credit: Aruna Chandrasekhar.

Contents

A Summary

This is NOT the full report – only a summary. The REPORT is available on request.

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Background

Generating electricity by burning coal is by no means cost-effective even if all safety measures are in place. If taken into account the human costs (loss of labour due to ill health and additional health care costs) and extensive damage to environment – coal is not cheap to generate electricity. For that reason, a number of countries in Europe have either stopped or are phasing out the use of coal to generate electricity. India is yet to take that route. Instead the country has opted for extensive coalmining and installing coal-fired electricity generating plants in states like Chhattisgarh.

Several studies, both in India and abroad, have established that the process of extraction of coal, particularly opencast mining, and generating electricity by coal-fired power plants produces a range of chemicals and heavy metals, both gaseous and solid. Every step in the generation of electricity by coal-fired thermal power plants – mining of coal, transportation, washing (preparation at the power plant), combustion, and the disposition of post-combustion wastes – carries serious risks on the health of miners, plant workers as well as the populations living around the mines and power plants. Table 1 is an overview of the consequences of coal mining and coal-fired electricity generation on environment and health.

A recent study[1] assessing the level of pollution due to coalmining and thermal power plants in Tamnar block of the district of Raigarh, Chhattisgarh has revealed the high level of fine particulate matters (PM2.5) and other toxic materials in air, land and water in the surrounding villages of Gare Pelma IV/2-3 mines and captive power plants. The current research is the follow up of the study to assess the health impacts of coalmines and power plants in that area.

1 Environmental Violations in and around Coalmines, Washeries and Thermal Power Plants of Tamnar & Ghargoda Blocks, Dist. Raigarh, Chhattisgarh: Report of Fact Finding Team (Nov. 2016).

Table 1. Consequences of coal mining and coal-fired electricity generation on environment and health.

Process	By-products	Pollutants	Environment	Health
Mining	Dust Rock	Particulate matters Heavy metals Silicon	Deforests and destruction of mountains; land erosion and consequences. Drying of rivers and streams. Impact on agro-diversity, wildlife and natural habitat. Soil contamination. Displacement of populations.	Miners: Accidents and fatal injuries; dust inhalation and respiratory illnesses. Population: Respiratory, Cardio-vascular, Neurological diseases; Chronic inflammatory conditions; Nutritional deficiencies due to loss of agriculture and forest produce.
Transportation	Diesel exhaust	NOx	Pollution of air along the route of transportation – road and rail.	Population: Respiratory (asthma, COPD), Cardio-vascular (cardiac arrhythmias), Neurological (ischemic stroke) diseases.
Washing	Slurry containing heavy metals	Arsenic; Mercury	Pollution of river, pond and ground water	Population: Nervous system; cardiovascular; digestive (poor appetite, nausea, vomiting) system related illnesses; and, cancer. (See below 'Waste')
Combustion	Harmful gaseous chemical	SO_2; NOx; CO Particulate matters Toxic metals: Arsenic; Mercury Cadmium; Nickel Chromium; Lead	Air pollution	Population: Respiratory (asthma, COPD, dry cough), cardiovascular (coronary heart disease, infarct - arterial blockage leading to heart attack), and nervous systems (ischemic stroke, loss of intelligence)
Waste	Fly ash	Toxic metals: Arsenic; Aluminium Boron; Cobalt Manganese Cadmium Lead; Vanadium	Contamination of air, land and water: - agricultural and pasture lands from disposal and landfills. - crops and vegetables from deposits from air. - surface water and ground water – river, stream, pond and shallow well from leaching and leaking.	Population: Cancer and nervous system impacts such as cognitive deficits, developmental delays and behavioural problems; also, can affect heart, lung, kidney and reproductive organs. Animals: from grazing contaminated grass and thereby into the food chain. Fish: from contaminated ponds and lakes.

The study

About the research

The research question: Are there toxic chemicals and heavy metals in air, land and water around the mines and power plants in the Tamnar block, Raigarh, Chhattisgarh? If so, are the population living close by exposed to such toxic materials? Do these toxic materials have any bearing on the health of the population in question?

Who did the research? How was the research conducted? A team of public health professionals with considerable experience in occupational and community health in tribal communities and environmental researchers jointly conducted the study with active participation of local organisation and residents of villages under the study. A brief note of the researchers is attached in Annex 1.

The research comprised three inter-dependent studies, 1) a house-to-house survey to document health complaints of the residents of target villages (self-reported illnesses); 2) medical examinations of residents by a team of competent doctors; 3) identifying the pollutants in air, water, soil, fly ash and sediment the population in question exposed to.

Research protocols: The study has maintained all standard protocols – approval of the survey and its tools by an ethical committee; proper training of interviewers; endorsement and support of relevant authorities at the state and district levels[1]. Standard procedures were maintained in the collection of environmental samples and were tested at a well-equipped and recognised laboratory.

Study sites, participants and environmental samples: Three villages, Sarasmal, Kosampali and Dongamouha, within 3 kilometers of surface coal mining and/or coal-fired power stations, were studied of which all households in one village (Sarasmal), and every third and fifth household for Kosampali and Dongamouha respectively were surveyed.

With prior consent, the house-to-house survey was conducted using a set of structured questionnaires. Health survey questions included symptoms related to respiratory, cardiovascular, musculoskeletal, neurological, gastrointestinal, skin and other similar contact related complaints. Also, the respondents were asked if they had been diagnosed with heart disease, stroke, hypertension, diabetes, kidney diseases, chronic obstructive pulmonary disease (COPD) or asthma. In addition, the survey included information on demographics, land yields, household assets, animals in possession, height and weight of individuals to calculate Body Mass Index (BMI), smoking and alcohol habits, exposure to smoke in households from burning coal as cooking fuel, water sources for drinking, bathing and household usages, and information about members in a household if working in coal mines or coal-fired power plants and thereby any additional exposure to coal dust and toxic chemicals.

[Note: The research focuses on regular residents living in close proximity of coalmines/ power plants, not miners or power plant workers as such. It is to be noted that a section of the population in these study villages are migrant workers who reside temporarily; the research does not include such residents. These migrant workers, when ill, normally return to their origin villages for treatment and care. In

1 Patients needing further medical examinations and clinical investigations were sent to the state and district health authorities.

other words, a comprehensive study of health impacts of residents who work in mines/plants would require tracking the ill migrant workers as well.]

Altogether 132 households (Sarasmal 82; Kosampali 27; Dongamauha 23) participated in the survey, the number of individuals totalling 515. A total of 205 individuals (including children) attended makeshift clinics with their health complaints (Sarasmal – 78; Kosampali – 39; Dongamahua – 88).

A total of 28 samples (4 air samples, 7 water samples, 9 soil samples, 2 fly ash and 6 sediment samples) were collected from villages namely Sarasmal, Kosampali, Regaon (upper and lower), Dongamauha, Kodkel, Dhaurabhata and surrounding pasture lands.

Please find Annex 2 for the details of samples, their locations and the pollutant sources i.e. mines or power plants or coal washeries.

House-to-house Survey

- Demography and socio-economy
- Occupation - if miner/plant worker
- Water source - drinking and other use
- Cooking fuel - coal and non-coal
- Smoking and alcohol habits
- Body Mass Index (BMI)
- Common health complaints
- Major medical conditions - respiratory, cardio-vascular, kidney and so forth.

Health impacts of toxic contaminants in coal ash

A range of toxic materials from coal and coal-fired power plants, particularly those found at coal ash disposal sites, are released into the environment. All have the capacity to affect human, animal and organic health as a result of direct contact, inhalation and ingestion or through food chains. Toxic substances commonly emitted in gaseous forms or through coal ash, in addition to NOx, CO and PM2.5 include arsenic, antimony, boron, cadmium, chromium, lead, mercury and selenium significantly affect organic health[25], as highlighted in Diagram 1.

ANTIMONY

Antimony exposure can occur as a result of gaseous pollution from coal-fired power plants causing respiratory irritation, skin lesions and gastrointestinal symptoms. Antimony trioxide is also a carcinogen affecting human health.

ARSENIC

A known toxic substance, arsenic causes a variety of adverse health effects. Contaminated drinking water is a primary route of arsenic exposure. Chronic exposure to arsenic in drinking water can cause several types of cancer, including skin, urinary bladder, lung and kidney cancer. Recent studies have also linked arsenic ingestion to cardiovascular disease and diabetes mellitus. Both the levels and duration of exposure are significant factors in the potential development of cancer. Ingestion of arsenic can lead to damage of nervous systems, cardiovascular conditions, and urinary tract cancers. Inhalation and absorption through skin can result in lung cancer and skin cancer.

BORON

While boron, a trace mineral occuring in plants and environment. has medicinal properties in small quantities, it poses a health risk when occurring in soils contaminated by pollutant sources such as coal ash from coal-fired power plants. Children living near waste sites are likely to be exposed to higher-than-normal levels of boron through dust inhalation and contact with contaminated soil. An inhalation of moderate levels of boron can cause irritation to the nose, throat, and eyes. Ingestion of large amounts through food or drinking water can also result in damage to the testes, intestines, liver, kidney, and brain.

CADMIUM

Cadmium is a hazardous metal present in fly ash or released into the environment during storage, transportation, or through landfill. Exposure to this metal can also occur through the ingestion of shell-fish and plants grown on cadmium-contaminated soils. Typically, however, cadmium exposure resulting from inhalation of dry coal ash represents a higher level of absorption which results in chronic obstructions leading to lung disease and kidney conditions. It is also a suspected lung carcinogen.

Cadmium may also be related to hypertension and increased blood pressure. Cadmium also affects calcium metabolism and can result in bone mineral loss and associated bone pain, osteoporosis and bone fractures.

CHROMIUM

Chromium in the form of chromium-VI is a highly toxic substance frequently found in coal ash. When inhaled in large amounts, Chromium- VI can cause respiratory problems such as asthma and wheezing, nose ulcers and lung cancer.

Chromium-VI can be ingested through contaminated water causing stomach and small intestine ulcers. Frequent ingestion can further cause anemia and stomach cancer while direct skin contact by some compounds of Chromium (VI) can result in skin ulcers.

LEAD

Lead is a heavy metal which is damaging to the nervous system upon entry to the human body. Exposure leads to neurotoxicity, developmental delays, hypertension, impaired hearing, impaired haemoglobin synthesis and male reproductive impairment. Harmful levels of lead exposure can occur in drinking water contaminated by coal ash and coal ash contaminated soils.
There is no safe level for lead exposure, particularly for children.

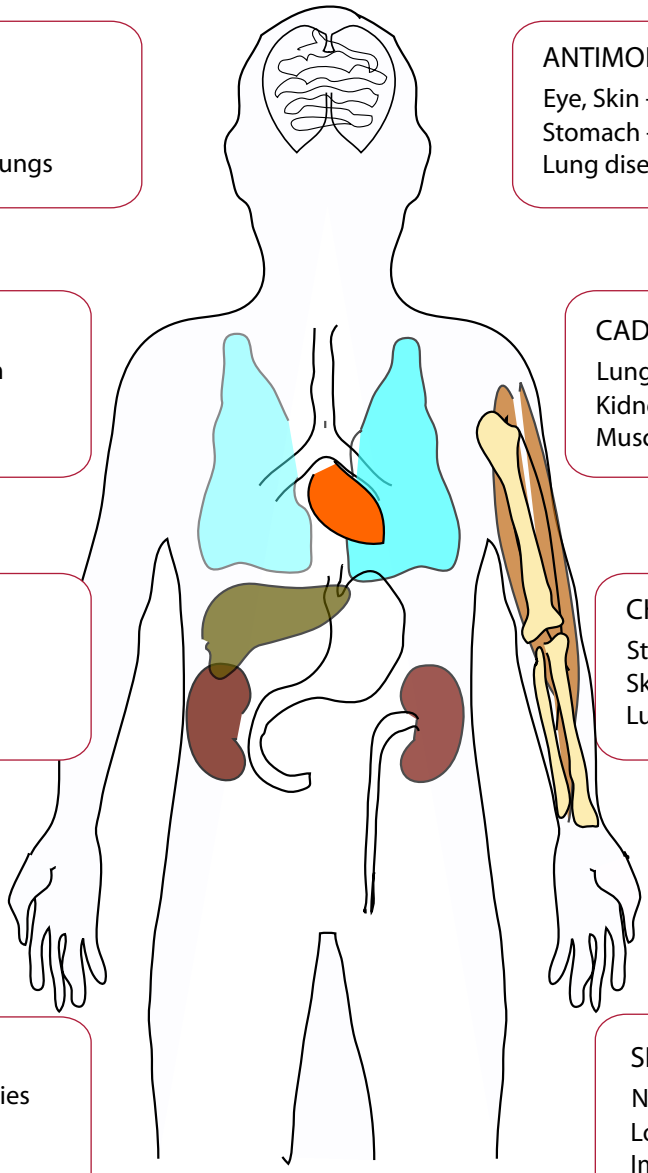
MERCURY

As with lead, mercury, found in and around coalmines and coal-fired power plants, is known for its neurotoxicity. Mercury is typically emitted through coal ash and converted by bacteria when reaching soil and water sources into an organic compound, methylmercury. Methylmercury gets into the food chain, particularly through fish. Mercury is particularly toxic to the developing nervous system. Mercury exposure during gestation, infancy, or childhood can cause developmental delays and abnormalities, mental retardation and behavioural problems.

SELENIUM

Selenium, an essential nutrient, is used by the body in a variety of cellular functions. However, deficiencies or excesses of selenium are harmful to body. Selenium enters the body through food chain typically linked to fish or plants absorbing the metal. Excess intake of selenium can result in a host of negative neurological conditions including impaired vision, paralysis, and even death.

Diagram 1. An overview of the effects of eight highly toxic pollutants on human body.



ARSENIC
Nervous system
Cardiovascular
Cancer - urinary, skin, lungs

ANTIMONY
Eye, Skin - irritation
Stomach - pain, ulcer
Lung disease

BORON
Nose, Eye, Throat - irritation
Liver, Kidney, Intestines
Reproductive organs

CADMIUM
Lungs - COPD
Kidney, Hypertension
Musculoskeletal - joint pain, bone

LEAD
Nervous system
Developmental delays
Hypertension

CHROMIUM
Stomach & small intestine - ulcer
Skin ulcer
Lungs - breathing problems

MERCURY
Developmental abnormalities
Mental retardation
Behavioural problems

SELENIUM
Nervous system
Low appetite
Impaired vision

Results

Findings

Already mentioned earlier that the research covered all households in Sarasmal (present at the time of the survey and medical examinations) as opposed to Kusampali and Dongamouha where only sample data were collected. In this summary note of the report, we will present the findings of Sarasmal only. The findings of Kusampali and Dongamouha (self-reported health complaints and medical examination records), though from sample data, are consistent with that of Sarasmal.

Demographics and socio-economy:

- Majority, if not all, are adivasi or from other backward castes.
- Majority depend on agriculture; residents say that since coal mining has been introduced in the area, their crops and forest products have been affected significantly.
- In Sarasmal, of the total 82 households, 45% do not depend solely on agriculture because of low crop yield, lasting less than three months of the year.
- One third of the population are underweight. In Sarasmal, of the 329 participants (not-recorded – 12) 113 individuas i.e. 34% are with below normal BMI.
- Most people use ponds and streams for bathing and other household usages. 85% of Sarasmal households.
- Despite the fact that the population live in the midst of coal mines, only a small number of households use coal; majority use natural fuel - firewood or cow dung.

The demographics, socio-economic status (main sources of earnings, land yield, household assets and animals such as cow/bullock/buffalo), cooking fuel and water sources, nutritional status (BMI) of participants, Sarasmal as well as Kusampali and Dongamouha are summarised in Table 2.

Pollutants:

A total of 12 toxic metals including Aluminium, Arsenic, Antimony, Boron, Cadmium, Chromium, Lead, Manganese, Nickel, Selenium, Zinc and Vanadium were found in the water, soil and sediment samples taken around the region. Of the 12 toxic metals, 2 (Arsenic and Cadmium) are carcinogens and 2 (Lead and Nickel) are probable carcinogens.

ALUMINIUM
ARSENIC
ANTIMONI
BORON
CADMIUM
CHROMIUM
LEAD
MANGANESE
NICKEL
SELENIUM
ZINC
VALADIUM

The air, water, soil and sediment sampling results show a very concerning level of harmful substances that adversely effect health. Heavy metals found in the samples are well known toxins and their effects on human health have been well documented. The measurement of such toxic substances from the areas of human settlements is indeed a cause for concern. Pollutants found in air, water, soil, fly ash and sediment samples is summarised in Table 3. For details of the pollutants and their levels, please consult the report 'POISONED' (available on request).

Table 2. Descriptive summary of study participants by location (total participants =515).			
Demographics; Assets; Water and cooking fuel use	Sarasmal	Kosampali	Dongamouha
Households	82	27 (81)	23 (116)
Total participants	341	72	102
Gender (%)	(n=341)	(n=72)	(n=102)
Male	44	42	39
Female	56	58	61
Age (%)	(n=341)	(n=72)	(n=102)
Up to 5 yrs	8	12	3
6-17 yrs	22	14	26
18 – 29 yrs	23	15	20
30 – 49 yrs	27	35	30
> 50 yrs	20	24	21
Caste/tribe/class (%)	(n= 82)	(n= 27)	(n= 23)
Schedule tribe	68	85	22
Schedule caste	0	7.5	13
Other backward class	32	7.5	65
Other (includes Hindus/upper class)	0	0	0
Main source of earning (%) *	(n= 173)	(n= 41)	(n= 24)
Agriculture	59.5	41.5	54.2
Miner/plant worker	15	19.5	33.3
Labourer/Migrant	25.5	39	12.5
Land yield %	(n= 82)	(n= 23)	(n= 23)
Reasonably good (crop lasting the whole year)	22	17	9
Moderate (crop lasting 7-9 months)	4	0	4
Not enough (crop lasting 4-6 months)	29	35	13
Low or no (crop lasting <3 months or no yield)	45	48	74
Animals (cow/bullock/buffalo) %	(n= 72)	(n= 7)**	(n= 23)
Reasonably sufficient (>4 animals)	21	14	13
Moderate (3-4 animals)	10	43	9
Just manageable (2 animals)	18	14	13
Low or no (1 or no animal)	51	29	65
Household assets (Pump set/Motor Bike/Television/ Mobile phone + Bi-cycle) % ***	(n= 82)	(n= 18)	(n= 21)
Reasonably good (3 or 4 items + Bicycle)	45	67	67
Moderate (2 items + Bicycle)	13.5	5.5	14
Not enough (1 item+Bicycle or 2 but no Bi-cycle)	13.5	5.5	0
Low or no (1 item or no)	28	22	19
Nutritional status/Body Mass Index %	(n = 329)	(n = 70)	(n = 99)
Overweight	13	27	19
Normal weight	53	41.5	54
Underweight	34	31.5	27

Water source – drinking % ****	(n= 87)	(n= 25)	(n= 23)
Shallow well	78	88	35
Pond	5	0	0
River/stream	1	0	0
Other (deep well/tanker supply)	16	12	65
Water source – household usage % *****	(n= 119)	(n= 12)	(n= 30)
Shallow well	32	67	57
Pond	53	0	37
River/stream	6	16.5	0
Other (deep well/tanker supply)	9	16.5	6
Cooking fuel usage %	(n = 77)	(n = 24)	(n = 23)
Coal	6.5	8	4
Bio-fuel (firewood/cow dung)	61	79	92
Both	32.5	13	4

* No of adult respondents (not households); does not include 'homemaker', 'migrants' or students.

** Response level is too low.

*** This is not a comprehensive socio-economic survey, rather a simplistic data of certain non-consumable items in possession. Household consumption expenditures, semi-durable goods or assets were not included in the survey questionnaire.

**** Some households use more than one source; also, there are non-responses - hence the number varies with that of households.

***** As above.

Tabole 3. An overview of the pollutants found in air, water, soil, fly ash and sediment samples.

No	Sample	No of samples	Analysed for	Results
	Air	4	PM2.5 Toxic heavy metals (Arsenic; Lead; Nickel; Manganese; Silicon; Aluminium; Calcium; Cadmium)	The aggregate levels of toxic particles in PM2.5 in Sarasmal, Kosampali and Dongamahua are higher than the permissible standard set by the Indian MoEF standard. PM2.5 in one location (Sakta Sitapur) adjacent to the above three villages is strikingly high and exceeds all standards – WHO, USEPA and Indian Standard. Toxic metals like Arsenic, Manganese, Nickel and Silicon all exceed the permissible standards.
	Water	7	Aluminum; Arsenic; Boron; Cadmium; Chromium; Lead; Manganese; Selenium; Total Dissolved Solids	All toxic metals have been found in the samples; Arsenic and Manganese levels are strikingly high. The levels of Aluminum, Boron, Cadmium and Selenium – all are above permissible standards.
	Soil	9	All above; in addition, Antimony and Vanadium.	All are above permissible standards – Vanadium, Chromium and Nickel in almost all samples, followed by Arsenic, Antimony, Cadmium and Lead.
	Fly ash	2	Aluminum; Iron; Titanium; Zinc; also, Calcium and Magnesium.	Aluminum; Iron; Titanium; Zinc levels are substantially high in soil due to fly ash deposit; Calcium and Magnesium are also found to be high but in variable amounts.
	Sediment	6	Arsenic; Cadmium; Chromium; Lead; and, Zinc.	Chromium found in all samples; Arsenic, Cadmium in most samples and are exceed the permissible levels.

Impacts on health

Health complaints (self-reported):
10 illnesses appear to be very common among the population under the study of which hair (hair fall and brittle hair), skin (dry skin, itching, discolouration, cracked sole), musculoskeletal (joint pain, body ache and backache), and dry cough complaints are most common.
In Sarasmal, of the 341 respondents 34% mentioned about loss of hair, 30% about joint pain and/or body ache, 29% about Skin complaints including cracked sole.

Please find Table 4 that describes these 10 common health complaints among the total respondents (n=341), and gender distribution.

Table 4. Major health complaints (self-reported) in Sarasmal village.

SL	Prevalence of health complaints in Sarasmal.	Number of individuals with specific complaints.				
		Male	Female	Total	% Female	% Total
1	Loss of Hair	27	88	115	76	34
2	Musculoskeletal	33	70	103	68	30
3	Skin complaints	40	60	100	60	29
4	Dry cough	19	71	90	77	26
5	Breathing difficulties	26	52	78	67	23
6	Eye complaints	31	47	78	60	23
7	Chest pain	24	41	65	63	19
8	Stomach related	25	35	60	58	18
9	Mental illness	11	31	42	74	12
10	Kidney related	3	32	35	91	10
Sarasmal: No of individuals responded to health questionnaire: 341 No of individuals screened by a medical team: 78 Total households: 82 Total population: 450 (aprox.)						
* reported by the respondents - not verified with investigation results.						

Discussion

Health-related complaints identified amongst participants in this study are significantly high. The nature of self-reported health complaints revealed from our house-to-house survey which were further confirmed by a team of experienced medical doctors highlights further serious cause of concern. These findings and concerns are central to discussion about the health impact of mining operations in Chhattisgarh.

The characteristics of health complaints identified by medical doctors conduction research for this study and their unique features are highlighted below as follow:

- **Very few local residents in the locality of mining concerns experience good health:**
A majority of residents from villages surrounding coal-mining industries in the Raigarh district of Chhattisgarh reported health complaints; of 341 respondents to our study in the village of Sarasmal, 296 or 87% of respondents described serious health concerns leading them to consult local doctors at private or governmental facilities. The striking feature of these medical complaints is that all are of a non-infective in nature.

- **Inflammation not infection:**
Table 7 above highlights chronic and non-infective inflammatory health conditions. Further medical examinations reveal that the causal agents of these health complaints arise from non-living organisms rather than from viruses, bacteria, fungi and parasites derived.

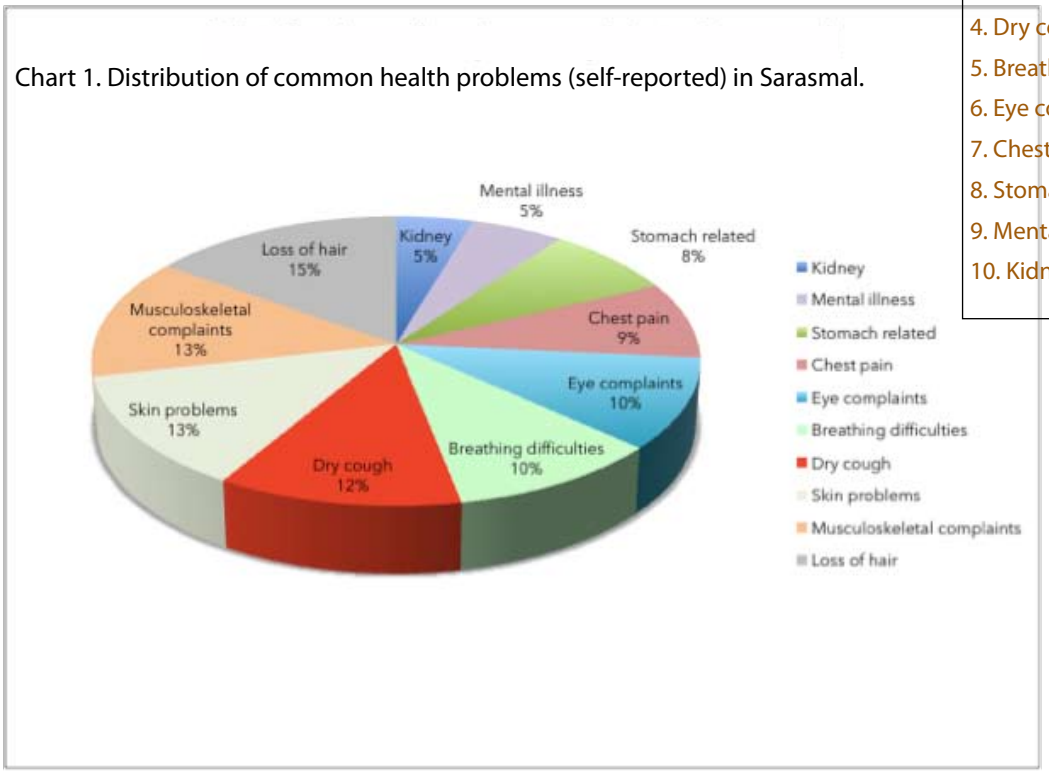
- **Multiple health complaints:**
A significant proportion of the population examined experience multiple health complaints related to more than one medical condition and anatomical systems including respiratory conditions, musculoskeletal disorders, skin and hair complaints. Individuals related that they developed these medical conditions simultaneously or within a year or so of one another. In certain cases individuals presented five or more health complaints alongside two to three unrelated medical conditions.

- **Individuals with multiple health complaints indicate more than one transmission route:**
Health complaints involving hair, skin, eye, joint, respiratory and stomach issues were commonly reported and/or diagnosed. In Sarasmal, of 228 respondents presenting at least one of a combination of complaints relating to hair, skin, eye, joint issues, 37 experienced 3 if not all four medical conditions, 82 experienced a minimum of two of the four stated anatomic source complaints. Similarly, of the 193 respondents presenting skin, joint or stomach complaints, 37 experienced all three medical conditions, 45 presented with two of the three conditions. Of Sarasmal's 341 respondents, a further 127 individuals presented coughs, 90 of which were 'dry' coughs. The prevalence of these specific health complaints suggest residents are exposed to substantial contact, ingestion or inhalation of pathogens.

- **More than one family member experiencing identical or similar health complaints:**
Multiple households were identified where two or more members experienced identical or similar chronic health problem complaints. An individual experiencing one or more health complaints annually is not a cause for major concern from a public health perspective. What is significant, however, is that a sizeable proportion of households visited by medical doctors reported identical or similar health complaints among more than one member resident.

- **Strikingly high levels of musculoskeletal health complaints among young age:**
The study has found a high proportion of musculoskeletal complaints in the form of joint

Chart 1. Distribution of common health problems (self-reported) in Sarasmal.



1. Loss of hair - 15%
2. Musculoskeletal - 13%
3. Skin - 13%
4. Dry cough - 12%
5. Breathing difficulties - 10%
6. Eye complaints - 10%
7. Chest pain - 9%
8. Stomach complaints - 8%
9. Mental illness - 5%
10. Kidney - 5%

pain, body ache and/or backache. The finding is striking because very few studies have recorded such medical complaints among miners or populations living in close proximity to mines. In Sarasmal, of 341 respondents 103 presented musculoskeletal complaints as did 36 of 78 individuals attending our medical study clinic.

Arthritis manifesting as joint pain or body or backache is common in older people. What is striking here, however, is that about one third of 103 patients presenting musculoskeletal complaints as part of this study were under the age of 30 and many as young as 15 or16 years of age.

- **Dry and not productive coughs:**

As mentioned above, 90 of 127 respondents presented dry coughs, rather than coughs accompanied by phlegm, which indicate the presence of an irritant pathogen or pathogens rather than commonplace respiratory infections arising as a result of living organisms.

- **Respiratory complaints and fine particulates:**

In some air samples the levels of very fine particulate matter (PM2.5) have been found to exceed the World Health Organisation (WHO) standard of 25µg/m3, the 24-hour cut; United States Environmental Protection Agency (USEPA) standard of 35µg/m3; and Indian Ministry of Environment and Forests (MoEF) standard of 60µg/m3. Shweta Narayan's of Community Health Monitoring's study of environmental degradation around coal mines, thermal power plants and ash ponds in the Raigarh district, 'Poisoned', suggests that PM2.5 levels are so high that the United States' Environment Protection Agency would have been compelled to issue an advisory for seriously unhealthy air quality. This indicator is consistent with our own findings that respiratory complaints presented by study participants are more likely to be caused by air pollutants than by living pathogens.

- **Burning coal as cooking fuel has little bearing on respiratory complaints:**

Having considered links between the use of coal as cooking fuel and health complaints resulting from the inhalation of dust and smoke, in spite of Sarasmal being surrounded by coalmines on three sides, of 77 village households surveyed (of which five were non-respondent), only 5 families (6.5%) use coal for cooking fuel, 47 i.e. 61% exclusively bio-fuel such as firewood or cow-dung and 32.5% used coal and firewood.

- **Skin complaints, cracked sole and hair loss:**

Of 78 individuals attending study medical clinics, 16 presented skin complaints in the form of itching, rashes and/or hyper-pigmentation suggestive of contact dermatitis; four patients presented extreme cases of severely cracked soles. While mild hair loss or cracked sole are normally perceived as 'trivial' health issues by the population in question which are not normally considered to merit medical examinations, 34% of total respondents in Sarsmal complained of dramatic hair loss.

Musculoskeletal, skin and hair loss complaints widely presented by study participants indicate possible manifestations of further chronic underlying health conditions.

- **Contact-induced skin complaints due to water usage cannot be ruled out:**

The study has investigated the quality of drinking water and sources used for bathing and other household usage. In Sarasmal 78% of households accessed drinking water via shallow wells or tube-wells while 59%, more than half of total village households bathed, washed and cooked in or with water from local ponds, streams and rivers. Water samples from local ponds and streams were found to be contaminated with toxic metals as indicated in Table 8. It is therefore possible that use of water from these source is linked to dermatitis and other complaints linked

to direct physical contact with potential irritants. As shallow well and tube well water have also not been tested to date, potential contamination of shallow underground water through surface water seepage via contaminated soil also cannot be ruled out.

- **A higher than average prevalence of mental illnesses is cause for concern:**

Higher than national average incidences of mental illness in the villages Sarasmal, self-reported as well as cases confirmed by a medical psychiatrist, indicate that 42 local individuals or 12% of total respondents have been reported as experiencing mental problems. Eight of a total of 78 residents attending medical clinics facilitated during this study have also been diagnosed as experiencing poor mental health afflictions ranging from anxiety disorders to clinical depression. While our temporary clinical was not equipped with formal psychiatric examination facilities, significant medical and anecdotal evidence of a rise in poor mental health and potential mental disabilities detected amongst villagers living adjacent to mining processing plants is cause for concern. Further research is urgently needed to categorically explore social, economic factors or pollutants potentially causing neurological disorders amongst local indigenous residents.

- **Inverse relationship between health and socioeconomic-nutritional status does not explain health conditions detected amongst participants:**

The agriculture and natural resource-based economy of the local population has been affected significantly by the introduction of coal mining and coal-based industries into the Raigarh region. This has led to a substantial sector of the population struggling to survive on very limited sources of income, particularly where dependent upon agricultural resources. In light of the changing viability of traditional farming or agricultural subsistence amongst local residents, a sizeable percentage have engaged in alternative forms of employment with apparent improved income-generation evidenced through the acquisition of assets such as motorbikes, televisions, pump sets or bicycles.

In Sarasmal where 45% if residents no longer depend on agriculture because of low crop yields lasting less than three months of the year or not yielding crops at all, 37 out of 82 households enjoy relatively better living standards as exemplified by consumer or financial assets. On the other hand, nutritional status of the population remains a concern with 113 or 34% of 329 participants being under-nourished.

Upon further analysis, local health complaints fail to substantially correlate with participants' broader economic and nutritional status thus suggesting significant negative impact of pollutants on local residents experiencing higher than expected health complaints.

Remarks

The findings of this study are significant and demand immediate measures. *Health and Environmental Impact of Coal Mining in Chhattisgarh* reveals that large-scale mining, coal-fired power plants and associated industries have inflicted lasting negative impacts on the population living for generations in the Raighar region of Chhattisgarh. Their environment, physical and mental health have been compromised, as revealed in our study of village populations, through exposure to worrisomely high levels of toxic heavy metals found in air, water, soil and sediment samples.

Several previous studies in India and elsewhere have documented the existence of pollutants in the vicinity of coalmines and coal combustion processing plants. Also, studies in the UK and USA have assessed health conditions of residents living adjacent to coal mines or coal-fired power plants by looking into their medical records. The findings of *Health and Environmental Impact of Coal Mining in Chhattisgarh* are consistent with and therefore build upon the findings of previous studies.

Few, however, are as comprehensive as this current piece of research. While exploring levels of toxic pollutants from surface mining and coal-fired power plants in communities living nearby and investigating self-reported health complaints of local people through extensive house-to-house surveys, it has also further validated their conclusions through formal medical examinations To conduct a comprehensive study of this nature was not an easy task – it required time, means, expertise and effective planning. It is hoped that this crucial medical and environmental investigation into the issue will be supplemented by further research revealing the nature and extent of some of the unexplored health impacts such as kidney, diabetes and the prevalence of cancers, and will offer an even broader picture of links between coal mining activity and health.

The presence of high levels of pollutants originating from coalmining and coal-fired power plants adjacent to their lands indicate a strong likelihood that such toxic substances are linked to their poor health. The research also finds that extensive mining and installations of coal-fired power plants and coal mining on a massive scale have negative impacts on socioeconomy of the population – their agriculture, natural resource-based economy, culture and the safe environment. These populations have been living in the area for generations but now struggle to survive as they have lost their lands, rivers and forests.

The dispossession of land has impacted on physical and mental health of the population; the shirking of forest cover and rampant pollution have destroyed the environment. Populations are forced to migrate or to work in mines and industries as temporary workers. Local inhabitants rightly demand that the Forest Rights Act of India, 2006, (that recognises the forest rights of scheduled tribes and other traditional forest dwellers) and the Panchayats Extension to the Scheduled Areas (PESA) Act, 1996, (that ensures self governance through traditional Gram Sabhas for people living in the Scheduled Areas of India) with their true spirit. These Acts will ensure the communities to have control and access over their own natural resources and environment.

The human and environmental costs are way too high to generate electricity by burning coal. It is desirable that the government of India adopts policies to phase out coal and protect forest and hills by stop surface mining without delay.

Recommendations

The findings of the research dictate the following recommendations focusing on people and pollution. These actions suggested below are in line with the demands of the local communities. Authors of this report hope that relevant authorities will take immediate measures before further damage to people and environment.

1. Conduct an in-depth study to identify the nature and extent of pollution in communities around coalmines and coal-fired thermal power plants, and undertake clean up measures - air, soil and water sources (surface and underground).

2. Provide proper health care and specialised treatments free of cost for all residents living within 5 KM of coalmines and coal-fired power plants.

3. Undertake measures so that the populations have safe water for drinking and other uses.

4. Initiate comprehensive and continuous monitoring of emissions in air, soil water sources, drinking water and fish in the region.

5. Apprehend polluters and take corrective remediation action to bring the levels of dust and heavy metals in residential areas to below detection limits.

6. Award the affected families punitive damages for responsible companies causing pollution neglecting norms and standards.

7. Impose a moratorium on any further expansion of the existing mines or setting up of new coalmines until comprehensive health impact assessments of the mines and power plants are completed and its recommendations are implemented.

Annexes

Annex 1. About the authrs

Ms Rinchin

Ms Rinchin is a writer and environmentalist. She has been working with people in the research area for the last 5 years or so, and has played a significant role in conducting the research.

Dr Prabir Chhatterjee

Dr Prabir Chatterjee is a medical doctor and community health specialist, trained in Christian Medical College, Vellore.

He has extensive experience in community health and has worked with TB patients in Hiranpur, with WHO in Godda (both in Jharkhand) and with UNICEF in Raiganj (North Bengal).

Dr Manan Ganguli

Dr Manan Ganguli is a medical doctor, trained in Calcutta (Kolkata) University, and has an MSc (in Radiation Biology) from London University. He has worked for over 30 years in the field of community health, both in India and abroad, and has considerable experience in community health, planning and evaluation.

Dr Ganguli works closely with a community-based health programme in Jharkhand. He has worked with a number of international organisations, namely International Federation of Red Cross/Crescent in South, South-East, Central Asian countries and in Africa.

Dr Smarajit Jana

Dr Smarajit Jana is a medical doctor and public health specialist who served as Epidemiologist at the All India Institute of Hygiene & Public Health, and as associate professor in community medicine in medical colleges. He also worked as National Advisor to National AIDS Control programme, Ministry of Health and Family welfare, India.

Dr Jana has conducted several research programmes supported by ICMR and other

Annex 2. Details of samples and their locations: 29-30 May, 2017.

SL	DATE	SAMPLE ID	SAMPLE LOCATION & DESCRIPTION OF THE SITE
1.	18.05.2017	AS1	Sample taken from the top of the house of Mr Ramsay Yadav in the village of Kosampali on the eastern side of the coalmines.
2.	19.05.2017	AS2	Sample taken from the top of the house of Mr Nehru Agriya in the village of Sarasmal on the eastern side of the coalmines.
3.	20.05.2017	AS3	Sample taken from the top of the house of Mr Jaybandhu Patel in the village next to Dongamahua Captive Power Plant in village of Dongamahua.
4.	24.05.2017	AS4	Sample taken from the top of the house of Mr Narayan Sidar in the village Sakta Sitapur about 4 kilometers from the coal mines and power plants
5.	29.05.2017	SS1 (Sediment)	Sample of the sediment from a water stream that leaked out of the JPL's ash pond (taken in Regaon village). Several such water streams were seen leaking out of the pond through various channels. The sample was collected in the presence of the village head Pralhad Kumar Sidar.
6.	29.05.2017	SS2 (Sediment)	Sample of sediment from the JPL's fly ash dump taken from the road across the village Regaon.
7.	29.05.2017	WS1 (Water)	A water stream, greyish in colour, flows out from the ash pond through the agricultural field of the village. Water from this stream meets the local canal and eventually the river Kelo. Water is used for agricultural purposes, also for bathing by local residents. Water samples were collected in the presence of the village head Pralhad Kumar Sidar.
8.	29.05.2017	FAS1 (Fly ash)	The local residents complain that fly ash from the JPL power plant is dumped all around the village. The site from where the sample was collected was a plot of government land allocated for the Awas Yojna (low cost public housing programme). This land is located between the JPL power plant and its ash pond.
9.	29.05.2017	BSS1 (Soil)	The sample was collected from a private land owned by Mr Satyavadi Gupta, about 100 meters south from the JPL fly ash pond. At the time of the sampling, the crop in the field was observed covered with fly ash.
10.	29.05.2017	WS2 (Water)	Sample was taken from Nishad pond at Kunjemura village. Villagers complained of the presence of ash deposit on the water. Water from this pond is used for drinking and washing purposes. The pond is located about 400 meters North of JPL's flyash pond. The sample was collected in the presence of BDC Ms. Vidyavati Sidar.
11.	29.05.2017	BSS2 (Soil)	The sample was taken from a private land owned by Mr Shivcharan Nishad, about 350 meters North from the JPL flyash pond. At the time of the sampling, the field and crop were covered with fly ash. The sample was collected in the presence of BDC Ms. Vidyavati Sidar.
12.	29.05.2017	WS3 (Water)	Water sample from the village pond in Kosampali adjacent to JPL coal mine. Water from mine is directly emptied in the pond. Water is used for bathing, washing and other household purposes. Residents complain of itchiness in skin after using the water.
13.	29.05.2017	FAS2 (Fly ash)	Fly ash sample collected in Kosampali village. Fly ash generated at the Tamnar Power Plant is regularly dumped in the area.
14.	29.05.2017	BSS3 (Soil)	Sample was collected from a private land owned by the aunt of Mr Kanhai Patel. The land was black in colour possibly due to coal dust; farming on the land has been abandoned due to repeated crop failures. The land is within 50 meters from the coalmine.
15.	29.05.2017	SS3 (Sediment)	Sediment taken from the banks of Karra nala in Kosampali/Sarsmal village. The water is used for irrigation purposes. This local canal carries water from the Jindal CHP coal washery. The canal later joins river Kelo.

16.	29.05.2017	SS4 (Sediment)	Sample collected from the banks of Bendra nala, a canal that flows from Dongamauha Captive Power Plant. The water is used for irrigation, washing and other household purposes. This canal later meets river Kelo. The sample was collected in the presence of Mr. Dileep Sidar.
17.	29.05.2017	BSS4 (Soil)	Soil sample taken from forest behind DCPP. While collecting the sample, flakes of fly ash were falling on area. The sample was collected in the presence of Mr. Dileep Sidar.
18.	29.05.2017	SS5 (Sediment)	Sample taken from a local canal that receives water from Jindal Coal washery in village Kodkel. The water from the canal is used for irrigation purposes.
19.	29.05.2017	BSS5 (Soil)	The sample was collected from a private land owned by Mr Chaitram Patel in Kodkel village. The land used for growing paddy depends on water from the local canal.
20.	29.05.2017	BSS6 (Soil)	The sample was collected from a private land in Kodkel village. The land uses water from the local canal to grow paddy.
21.	30.05.2017	WS4 (Water)	Sample was collected from Bendra Nala behind DCPP at the confluence of effluent channel from the power plant and mines. At the site, the water appeared to have an oily film with a distinguishing odour of some oil.
22.	30.05.2017	SS6 (Sediment)	Sample was collected from Bendra Nala behind DCPP at the confluence of effluent channel from the power plant and mines. There was an oily film on the water with sharp oil like odour.
23.	30.05.2017	BSS7 (Soil)	The sample was collected from a private land owned by Mr. Vijay Ram Bhoihar in Beljhor village. The land uses water from the local canal to grow vegetables. The land is located right behind DCPP and is mostly covered with fly ash from the plant.
24.	30.05.2017	BSS8 (Soil)	Soil sample collected at the entrance of Dhaurabhata primary school. The place is by a road on which several hundreds of trucks pass by every day carrying coal. The entire place was covered with coal dust.
25.	30.05.2017	WS5 (Water)	Sample collected from a local pond (Dongri talab) in Dhaurabhata village; the pond in an abandoned mine. The water used for bathing and cleaning purposes was red in colour.
26.	30.05.2017	BSS9 (Soil)	Roadside soil sample collected at Banjkhod roundabout. Several hundreds of trucks carrying coal form Hindalco mines pass through the road daily. The entire place was covered in coal dust.
27.	30.05.2017	WS6 (Water)	Sample collected from a local canal near village Kodkel that receives water from Hindalco underground mine. The water, black in colour, is used for irrigation purposes. Local residents also use this water for washing grains and for bathing purposes.
28.	30.05.2017	WS7 (Water)	Sample of drinking water in Kodkel village. Villagers report of getting coal particles in their water and suspect that water from mines is being channelised as drinking water by the mining company.

Back cover photo: Children from Kosampali village walk past a sign signalling blasting in the Gare Pelma/2&3 mines. Many houses here are less than 200 mitres from the mine's blasting site.
Credit: Aruna Chandrasekhar.

People First Collective, India are a group of professionals, environmentalists and social activists who are deeply concerned about the economic growth of India today that is based on inequality and focuses on indiscriminate mining and associated industries. The Collective believe that the 'development' policies of the government disregard the true interest of people, dalits and adivasis in particular, depriving their rights over land and natural resources, and thereby have in icted irreparable damage to the environment.

People First Collective, India will continue to focus on environmental health issues and violations of environmental norms and rights of people, be it land or basic human rights. It will undertake social researches similar to the study mentioned above and will promote in relevant forums within India and internationally.