The Health and Environmental Impact of Coal Mining in Chhattisgarh

A Report

November 2017

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This report is dedicated to people of Sarasmal, Kosampali, Dongamahua, Libra, Kodkel and surrounding villages in the Raigarh district of Chhattisgarh who face a serious challenge to their survival as their ancestors lands are lost to the profitable development of coalmines and power plants.

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

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Health and Environmental Impact of Coal Mining in Chhattisgarh's research team includes:

Ms Rinchin, a writer, an environmentalist and a researcher who has played a significant role in conducting this study into the Health impact of coal mining in Chhattisgarh.

Dr Prabir Chatterjee, a medical doctor and community health specialist, trained in Christian Medical College, Vellore (India). His extensive experience in community health includes work with TB patients in Hiranpur and with WHO in Godda, Jharkhand and with UNICEF in Raiganj ,West Bengal.

Dr Manan Ganguli, a Calcutta (Kolkata) University-trained medical doctor who holds a Radiation Biology MSc from London University. He brings considerable experience gained over three decades both in India and abroad in the fields of community health, planning and evaluation.

Dr Smarajit Jana, a medical doctor and public health specialist who served as Epidemiologist at the All India Institute of Hygiene & Public Health and as an Associate Professor in Community Medicine at several medical colleges. He has conducted several research programmes supported by ICMR and agencies including the World Health Organisation (WHO) and was a National Advisor to India's Ministry of Health and Family Welfare's National AIDS Control programme.

Research for *Health and Environmental Impact of Coal Mining in Chhattisgarh* has been undertaken by a team of medical and environmental professionals who have worked in partnership with People First Collective, India and Adivasi Dalit Mazdoor Sangathan, a social organisation in the Raigarh district of India's Chhattisgarh state.

People First Collective, India (PFCI) brings together professionals, environmentalists and social activists deeply concerned at evidence of complete disregarding for human rights and the destruction of our natural environment in the wake of India's economic 'miracle'. For as long as current indiscriminate mining and industrial practices inflict irreparable damage to the land and natural resources on which Dalit and Adivasi people have dwelt for generations, PFCI will continue to undertake social research, investigate and highlight violations of environmental norms, environmental health and the basic human and land rights of India's most disenfranchised people.

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A report

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

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Abbreviations

Adivasi	Indigenous population in India
BDC	Block Development Committee
BMI	Body Mass Index
CHP	Combine Heat and Power
CO	Carbon monoxide
CPP	Captive Power Plant (a power generation facility operated by an industrial or commercial user for their own energy consumption.
IEA	International Energy Agency
Hectare	A metric system unit of square measure; 1 hectare (ha) area is equal to 10,000 square metres; 1 ha is equivalent to 2.47 acres (imperial unit of square measure).
JPL	Jindal Power Plant
Micron	One millionth of a meter.
MoEF	Ministry of Environment and Forest and Climate Change, India.
Mt	Million tonnes
NOx	Nitrogen oxides
OBC	Other Backward Caste/Class
Opencast coal mining	Popular form of extracting coal from the earth by first removing the overlying soil and rock, then extracting the underlying coal; the end result is a sheared-off hill and a large open pit.
Particulate matter (PM)	Tiny particles of solid or liquid suspended in a gas or liquid, such as coal and mineral dust in the atmosphere.
PM2.5	Particles less than 2.5microns in diameter capable of damaging the lung lining.
PM10	Particles 10microns or greater are readily expelled from the lungs.
SC	Scheduled Caste
SHRC	State Health Resource Centre
SO_2	Sulphur dioxide
ST	Scheduled Tribe
TLDS	Total Dissolved Solids
USEPA	US Environment Protection Agency
WEC	World Energy Council (UK)

Acknowledgements

We are pleased to present this highly significant study of the human and environmental consequences of extensive and poorly monitored coal mining and coal-fired power generation in the Raigarh District of Chhattisgarh, India. Our findings raise an alarm on potentially lethal and unsustainable mining practices fast destroying our environment, land and forest resources farmed by local tribal people for generations.

Health and Environmental Impact of Coal Mining in Chhattisgarh draws upon the outstanding collective skills of local, Indian and international professionals, researchers, environmentalists, technical experts and residents of Sarasmal, Kosampali and Dongamouha who not only participated in the study but, alongside local institutions and organisations, helped make it happen. All are owed a debt of gratitude. Produced as a joint initiative with Adivasi Dalit Mazdoor Sangathan in the Chhattisgarh district of Raigarh who made local participation possible for this body of research, People First Collective, India extends their sincere gratitude. We look forward to continuing our meaningful collaboration for further studies.

Our study would be incomplete without the contributions of Shweta Narayan of Community Health Monitoring's August 2017 environmental study, 'Poisoned', and a fact-finding team producing a 'Environmental Violations in and around Coalmines, Washeries and Thermal Power Plants of Tamnar & Gharghoda Blocks, Dist. Raigarh, Chhattisgarh' study in November 2016.

A team of doctors from Kolkata, Dr. V. Indrani, Dr. Jyotirmoy Samajdar, Dr. Protim Roy and Dr. Smarajit Jana, conducted medical examinations for this study under rural Chhattisgarh's adverse hot summer weather in temporary clinical facilities. Raigarh District and Chhattisgarh health authorities extended invaluable support in their help to facilitate medical investigations and undertake ongoing referrals of patients at state and district health institutions as did the State Health Resource Centre in Raipur and field team members Saravanan Kumar, Yomeema Tejasvi, Kripalini Patel and Dr Arti Brokar in conducting the study. We all extend thanks to staff and the statistician at DURBAR, Kolkata who helped analyse medical data collated for this report.

Finally, we are grateful to Ms Daniele Lamarche for proofreading the manuscript and for her comments.

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Executive summary

Executive summary

In spite of the fact that coal mining for coal-fired power generation is one the most hazardous and damaging industries [1] such that governments of Austria, Belgium, Canada, Finland, France, New Zealand, Sweden, United Kingdom have pledged to phase out coal over the next decades[2], India, China, the United States and Russia continue to rely heavily on coal for the generation of electricity.

India is one of the world's major coal producers, ranking third after China and the United States[3]. Several national and international studies have established that the process of coal extraction, particularly opencast mining, and electrical generation by coal-fired power plants release a range of gaseous and solid chemicals and heavy metals into the atmosphere as a by-product of this process.

Every step in the generation of electricity by coal-fired thermal power plants – the mining of coal, transportation, washing and preparation at the power plant, combustion and the disposal of post-combustion wastes carry serious risks on the health of miners, plant workers and residents in the vicinity of mines and power plants.

Existing power plants in India, with few exceptions, are highly polluting- particularly as standards are only set for Particulate Matter (PM) rather than for all related pollutants including Sulphur dioxide (SO2), Nitrogen oxides (NOx) or heavy metals such as mercury. The PM standards are also lax. This research therefore crucially investigates the nature and impact of pollutants in air, soil, stream sediment and water on communities living close to opencast mines and coal-fired power plants in Chhattisgarh.

Research undertaken over the last two decade in Europe, the United States and the United Kingdom explore the environmental impact of coal mining on air, water and soil pollution; few to date however consider the public health consequences of coalmines and coal-fired power generation plants in parallel with environmental destruction.

The *Health and Environmental Impact of Coal Mining in Chhattisgarh* therefore seeks to explore the damaging impact of large scale coal industries in the Chhattisgarh state of India on its people and the environment in which they live in a call for urgent action to rethink policies and practices of meeting energy needs through destructive energy practices in light of an upsurge of clean, sustainable and healthier options available today.

Methodology

Research for this study was conducted amongst villagers who are long-term residents of the Sarasmal, Kosampali and Dongamouha villages in the Tamnar Block of the district of Raigarh, Chhattisgarh. All live adjacent to, or within a maximum 2-kilometre distance from coalmine and coal-fired power plants. Research sought to answer key questions such as:
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*?

Health and Environmental Impact of Coal Mining in Chhattisgarh is comprised three inter-dependent studies comprised of a) a house-to-house survey documenting self-reported health complaints raised by residents of villages living in close proximity of coal mining or processing plants as detailed in the appendix of this report; b) follow up medical examinations undertaken by a team of qualified and experienced medical doctors to ascertain the health profiles of residents interviewed and consider a fuller diagnosis of their reported health complaints; c) soil sampling of air, water, soil, fly ash and sediment pollutants emanating from coal mining and processing operations in the vicinity of villagers to determine the nature of pollutants to which they might be exposed.

The study has observed and maintained a good standard of research protocols including approval of our proposed survey protocols and tools by the SHRC Institution Ethical Committee, Raipur (Chhattisgarh), training of interviewers in good practices for community-based survey contact, endorsement and support from relevant state and district authorities. Medical data were collated by staff and staticians in Durbar, Kolkata and good standards of procedures were maintained in the collection of environmental samples and were tested at well-equipped and international-recognised laboratories including Chester LabNet (www.chesterlab.net), based in Seattle, Oregon, USA.

Data Collection

The house-to-house survey element of this study was conducted with the use of structured questionnaires exploring health symptoms amongst interviewees related to respiratory, cardiovascular, musculoskeletal, neurological, gastrointestinal, skin and similar contact-related chronic health complaints. The respondents were asked if they had been diagnosed with heart disease, stroke, hypertension, diabetes, kidney diseases, chronic obstructive pulmonary disease (COPD) or asthma.

The survey further explored the height and weight of individuals interviewed to calculate their Body Mass Index (BMI), smoking and alcohol habits, exposure to smoke in households from burning coal and cooking fuel, water sources for drinking, bathing and household usages. Further information was also sought about household members directly working in coalmines or coal-fired power plants who might experience additional exposure to coal dust and toxic chemicals.

In tandem with health issues, interviewers noted the demographics, land yields, household and animal husbandry assets to chart any inter-relations between household geographic, economic and nutritional status with physical and mental health profiles captured in this study.

A total of 515 individuals or 132 households – 82 in Sarasmal, 27 in Kosampali and 23 in Dongamauha – participated in the door-to-door household survey element of this study.

A further 205 adults and children – 78 from Sarasmal, 39 from Kosampali and 88 from Dongamauha – who attended medical check-ups facilitated in our temporary field clinics between 22nd and 24th of May, 2017 to further explore their health complaints.

Soil, Sediment and Water Sampling

A total of 28 samples detailed in Annex 2 - four air samples, seven water samples, nine soil samples, two fly ash and six sediment samples - were collected from the villages of Sarasmal, Kosampali, upper and lower Regaon, Dongamauha, Kodkel, Dhaurabhata and surrounding pasture lands. Further information is available in Annex 2 on the nature of samples, their locations and proximities to local mines or power plants or coal washeries.

Findings

Fuller details on our study's findings are described in the 'Results' sections of this report. The study is comprises of a health assessments of villagers from participating areas depicting their health profiles, health complaints highlighted in self-reported surveys of villagers from Sarasmal, Kosampali and Dongamouha which lie within a kilometre of coalmines or coal-fired power plants who were further examined by medical doctors in a temporary medical clinic set up for this study's purposes to achieve a clinical diagnoses of each participants' health conditions in parallel with an environmental assessment examining samples of air, water, soil, sediment and fly ash to ascertain the presence of pollutants in the local surrounding environment. While all long-term Sarasmal households present at the time of surveys and medical examinations undertaken between 22nd and 24th of May, 2017 were visited, resource constraints limited our survey in Kusampali to every third household and in Dongamouha, every fifth household. The findings of self-reported health complaints and medical examination records for residents of Sarasmal are therefore presented in more detail than the other two villages surveyed as part of this study.

Our research focuses on the health profiles of long-term residents living in close proximity to coalmines and power plants rather than amongst miners or power plant workers. As a comprehensive study of health impacts of residents who work in mines and plants would require substantial further tracking of ill migrant workers, where local village residents are themselves temporary migrant workers they have not been included in our research survey as they typically would return to their own villages if in need of medical treatment or care.

In addition to demographics and health information, samples of air, soil, sediment and water were collected from relevant locations of the above villages, surrounding streams, ponds and roadside fly-ash landfills.

Participant Demographics, Socio-Economic & Nutritional Status:

- A majority, if not all study participants were of Adivasi heritage or what is classified by the Indian government as of 'low' or 'backwards' caste or class backgrounds.

- The population of Sarasmal was entirely composed of Scheduled Tribes (STs), Scheduled Castes (SCs) or Other Backward Castes (OBCs) with 68% of residents identifying themselves as being of indigenous Adivasi heritage. A proportion of residents in all three villages are also migrant workers who were not considered in this study because of the temporary nature of their local residence.

- A majority of villages depended upon agriculture for their survival and say crops yields and forest production have significantly been affected by the introduction of coalmines to the area;
- On average, one-third of the respondents in all three villages are under-weight. In Sarasmal, of 329 participants including 12 for whom no records were logged, 113 individuals or 34% registered as being substantially below normal BMI.

Water Sources and Cooking Fuel Usage

- Most people depend upon underground water sources including shallow water, tube wells or a bore well, in the case of Dongamouha village, for drinking purposes. Bathing, washing and household water usage more commonly relied on surface water such as ponds and streams.
- In Sarasmal 78% of total households use shallow wells or tube-wells for drinking purposes with 6% relying on ponds and/or river streams. 59% of village households use ponds and river/streams for domestic tasks include bathing and washing;
- In spite of villagers live in the midst of coal mines, only a small proportion of those interviewed use coal for cooking - a majority use natural fuel in the form of firewood or cow dung instead.
- In Sarasmal of 77 households interviewed when excluding 5 non-respondent households, only 5 families or 6.5%) of village households use coal for cooking. 47 families or 61% of households used bio-fuel for cooking and the remaining 20? used coal and firewood. Similar patterns of cooking-fuel consumption were noted in the other two villages surveyed.

Pollutants

Air, water, soil and sediment sample results indicate the presence of worrisome levels of toxic substances that adversely affect human health. A total of 12 toxic metals including aluminium, arsenic, antimony, boron, cadmium, chromium, lead, manganese, nickel, selenium, vanadium and zinc were found in water, soil and sediment samples taken from sites detailed in Appendix II. Samples of these pollutant levels are also further explored in Community Health Monitoring's August 2017 environmental study, 'POISONED', which can be made available upon request.

Health Impacts

The nature of self-reported health complaints revealed in Health and Environmental Impact of Coal Mining in Chhattisgarh's house-to-house survey and further confirmed by a team of experienced medical doctors is cause for concern and discussion. Ten self-reported chronic health conditions prevalent among residents interviewed – and later examined by medical doctors - include hair loss – and brittle hair - musculoskeletal joint pain, body ache and backache, dry, itchy and/or discoloured skin and cracked sole and dry cough complaints.

The nature of health complaints detected and their unique features notably included:

- The alarming fact that very few individuals interviewed were without a health complaint;
- A majority experienced multiple health complaints;
- Family members often shared the same or similar health complaints;
- Higher than average prevalence of musculoskeletal health complaints was noted among young people;
- Individuals indicated more than one potential source of transmission for health complaints;
- A majority of health conditions logged were of an inflammatory rather than an infectious nature;
- A prevalence was noted of dry, mucus-less and non-productive coughs;
- Connections were likely between Fine Particulates and a high prevalence of respiratory complaints;
- Burning coal as cooking fuel has little bearing on respiratory complaints;
- Contact-induced skin complaints due to water usage cannot be ruled out;
- A higher than average prevalence of mental illnesses is cause for concern;
- Inverse relationship between health and socioeconomic-nutritional status does not explain health conditions detected amongst participants.

An extensive growth of mining, coal-fired power plants in the Raigarh region of Chhattisgarh since 2002 have inflicted adverse impacts on local residents living in the area for generations. *Health and Environmental Impact of Coal Mining in Chhattisgarh*'s research reveals that exposure to dangerous levels of toxic substances including heavy metals found in air, water, soil and sediment samples are likely to be connected to poor human health experienced by residents in the vicinity of these industries.

Introduction

Coal and Mining

A dangerous and hazardous operation, coal mining serves as a focal point for energy planners, health professionals and environmentalists. Coal, primarily used to produce electricity, is a fossil fuel mined for centuries deep underground. The goal is to remove coal from the ground as economically expediently as is possible. The advent of explosives and heavy machinery has also made surface mining, particularly opencast mountaintop coal removal, particularly cost-effective.

A perusal of the environmental, social and health impacts of coal mining and combustion studies worldwide indicates that while the occupational health hazards of coal mining are well documented, few studies consider the public health consequences of coalmines and coal-fired power generation.

A 2012 US-based study into the *Health Effects of Coal Electricity Generation in India*[4] correlates data, however, on particulate and gaseous emissions from power plants across the country with available United States data on lung cancer and cardiopulmonary mortality due to long-term exposure to fine particulate air pollution. While this study helps ascertain the health consequences of coal-fired power plant particulate and gaseous emissions in India, we are not aware of any other study which investigates and collates samples of air, soil, stream sediments and water pollutants in communities living adjacent to opencast mines and coal-fired power plants in India while simultaneously exploring the potential health impacts of these pollutants on these identified populations.

Coal Mining for Industry

Coal, broadly classified as 'Hard Coal' of a bituminous and anthracite variety and 'Brown Coal' of a sub-bituminous and lignite variety is a hazardous fossil fuel irrespective of the nature

of its variety or usage. With a gross calorific value not less than 5700 kcal/kg, 'Hard Coal' is considered as high to medium-rank in terms of high heat production, given a low moisture and ash content, and is mainly used as 'Coking' fuel in blast furnaces used by steel and metallurgical industries. Brown coal, on the other hand, with less or no 'Coking' properties, is mainly used in power generation and production of cement, fertilizer, glass, ceramic and similar industries. The quality of 'Non-Coking' coal can be improved when washed to remove rocks and reduce ash-producing contents to create what is termed as 'clean coal'. There is, however, no such thing as 'clean' coal – all varieties of coal mined and used produce toxic fumes and/or waste.

Despite the fact that coal mining vis-à-vis coal-fired power generation is one the most hazardous and damaging industries, and the fact that many governments have pledged to phase out coal over the next decades, this polluting fossil fuel provides 41% of global electricity and remains

an important source of electrical generation worldwide.

Coal kills but remains a popular form of electricity generation amongst governments. China, India, US, Russia and Japan collectively generate over 75% of global coal consumption. Please find Table 1 for an overview of coal production, imports and exports worldwide.

Environment and Health Implications

The use of coal has a variety of adverse impacts on our environment and health. Every step in the generation of electricity by coal-fired thermal power plants – coal mining, transportation, washing at power plants, combustion, and disposal of post-combustion wastes – carries serious risks to the health of miners, plant workers and populations living around the mines and power plants.

Before it is transported to power plants, coal is usually washed with polymer chemicals and large quantities of water to separate soil and rock impurities from the fuel.

Liquid waste, slurry or sludge which is a byproduct of this process is likely to contain heavy metals common to mined rock such as arsenic and mercury. The transportation of coal itself by rail or road produces toxic fumes including Nitrogen oxide and Particulate Matter in the form of diesel exhaust released into the air.

Depending on its variety and composition, coal burning releases over 70 harmful chemicals through Particulate Matters into the environment; typically they contain arsenic, cadmium, chromium, lead, manganese, mercury, nickel, silicon and oxides of sulphur, nitrogen and ozone.

Table 1. An overview of coal production, imports

Main producers, exporters and importers of hard coal in 2013 (WEC, 2014)					
Producers		Exporters		Importers	
Country	Mt	Country	Mt	Country	Mt
1. China	3561	1. Indonesia	426	1. China	327
2.USA	834	2. Australia	336	2. Japan	196
3. India	568	3. Russia	141	3. India	180
4. Indonesia	489	4. USA	107	4. South Korea	127
5. Australia	396	5. Colombia	74	5. Taiwan	68
6. Russia	274	6. South Africa	72	6. Germany	50
7. South Africa	256	7. Canada	37	7. UK	49
8. Kazakhstan	115	8. Kazakhstan	33	8. Turkey	28
9. Colombia	85	9. Mongolia	22	9. Italy	20
10. Poland	77	10. Vietnam	18	10. France	17
Rest of World	328	Other countries	67	Other countries	271
Source: New regulatory trends: effects on coal-fired power plants and coal demand - Herminé Nalbandian-Sugden. IEA Clean Coal Centre (December 2015).					

Coal combustion produces and emits gaseous by-products into the atmosphere or solid waste in the form of coal ash. Pollutant Particulate Matters (PM) primarily containing PM2.5, Sulphur dioxide (SO2), Nitrogen oxides (NOx) and Ozone gaseous emissions and heavy metal solid waste, namely mercury, are of serious concern among environmentalists and public health specialists. While posing significant threats to the environment, such pollutants are linked to respiratory, cardiovascular and neurological health issues and cellular inflammation leading to cancer and a range of chronic health conditions.

A review of research documents related to pollutant emissions both globally and in India from coal mining, coal-fired thermal power plants and allied industries and their correlation with health problems among populations exposed to such pollutants, with the exception of two carried out in the United Kingdom (UK), found a significant association between exposures to coal related pollutants and higher morbidity and mortality rates amongst exposed populations.

The UK studies, conducted by the department of Epidemiology and Public Health, University of Newcastle upon Tyne [5,6] referred to above, notwithstanding recorded higher consultations of children with General Practitioners in areas where opencast mining operated but did not find conclusive evidence of higher respiratory illnesses among exposed children to those representing control communities; however a second 2009 UK study, Douglasdale Community Coal Health Study[7], compared health statistics of populations living in the vicinity of Scotland's Douglas Valley opencast mining with that of a seaside town with little or no coal mining-related pollution, demonstrated strikingly higher levels of poor health in the form of chronic obstructive pulmonary disease (COPD), asthma, hypertension, hypothyroidism and cancer among populations living near opencast coalmines.

In the US, studies on the health of people living in proximity to opencast coalmines in Appalachian states in eastern US demonstrated higher morbidity and mortality of respiratory, cardiovascular, neurological and kidney diseases, even after correcting for the effects of covariates such as smoking and poverty.[8] '*Coal's Assault on Human Health*', a 2009 'Physicians for Social Responsibility' report elaborates the health effects of coal pollutants and highlights a higher prevalence of morbidity and mortality of respiratory, cardiovascular, neurological, heart and kidney diseases on a population at large, as well as negative environmental effects. [9] Chicago School of Public Health's 2013 research on the *Health Effects from Coal Use in Energy Generation*, further highlights evidence of the negative health and environmental impacts of causal pollutants linked to coal energy generation on respiratory, cardiovascular, neurological, life expectancy and climate change.[10] A 2015 University of Indiana Bloomington School of Public Health study by Michael Hendryx and Jennifer Entwhistle[11] of blood samples of adults living in close proximity to surface coal mining regions in West Virginia found significantly higher levels of C-reactive protein, an inflammatory marker predictive of risks for cardiovascular, respiratory and other chronic conditions disease, in comparison with that exhibited by control participants living in rural non-mining communities. The study is the first of its kind demonstrating the an elevated biological marker of poor health among resident near surface coal mining operations.

'Silent Killers', a 2013 Greenpeace International study[12] considering the health impacts of 300 operating power plants in the EU and predicted impacts of a further 50 planned plants echoes core findings of the aforementioned US-based Physicians for Social Responsibility report and highlights the health case for Europe to urgently replace coal power with green energy.

India's corporate giant, the Adani group, are currently engaged in a multi-billion US dollar coal project in central Queensland, Australia that involves expansion of opencast mining, rail transportation to sea port and constructing offshore shipyards. Environmentalists and social activists across Australia have stepped up a campaign to stop the project, as they fear imminent threat to environment, health of people and ecology. A review of available Australian and international literature about the health and social impacts on communities affected by coal mines, '*Health and Social Harms of Coal mining on local communities*', commissioned in 2012 by Australia's Zero Emission[13] suggests clear association between serious health and social harms in communities in Hunter Valley of New South Walesa, one of Australia's oldest and most productive coal mining areas, and the population's living around opencast coal mining and coal fired power stations.

A 2004 study '*Environmental Impacts of Coal Mining in India*'[14] comprehensively examines the environmental, health and socio-economic impacts arising in the course of the life cycle of coal - impacts on land, water, air, wild life and ecology; impacts due to blasting, transport and storage; impacts on health and safety of workers and, on society, concludes that while coal will remain a primary source of energy in India's economic growth and development, the consequences of coal-fired electricity on environment and health must not be ignored. India must adopt alternative strategies to meet its growing energy requirement.

As surface mining becomes more cost-effective and a popular approach to coal mining in India, studies[15,16] conducted by the Dhanbad-based Centre of Mining Environment of the Indian School of Mines assessed the quantity of Particulate Matters generated at an opencast coal mining site in Jharia coalfield, Dhanbad (Jharkhand) and found the work zone as well as ambient air highly polluted by dust in the study area. The latter report concluded that more stringent air quality standards need to be adopted in coal mining areas to reduce the harmful effects of coal mining on human health and vegetation. The report, '*Environmental and Social Challenges facing the Coal Industry*',[17] prepared by Prof. Gurdeep Singh highlights evidence that mining-induced environmental and social issues also lead to displacement and resettlement of residents linked to the loss of physical and non-physical assets including homes, communities, productive land, income-earning assets and sources, social structures, cultural identity leading to economic disparity, addictions and frustration.

Health and Environmental Impact of Coal Mining in Chhattisgarh has reviewed and adopted sampling techniques used in a study[18] conducted by the New Delhi-based Centre for Science and Environment which reveals high levels of mercury in drinking water, soil, fish samples found in the Singrauli region of north-eastern Madhya Pradesh and the adjacent Uttar Pradesh state which form a similar hub of opencast coal mines, thermal power stations and associated aluminium smelting, chemical, cement industrial and commercial operations to those found in the Raigarh region of Chhattisgarh.

An overview of the consequences of coal mining and coal-fired electricity generation on environment and health is presented in **Table 2**.

Table 2. 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	NO_x	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.

Coal mining in India

Coal mining in India

India is one of the world's major coal producers, ranking third after China and US. As its economic growth relies heavily on mining and industries, India has adopted an aggressive policy of coal mining for the facilitation of coal-fired power generation regardless of the environmental and health consequences to coal workers and populations living around mines and power plants. India is also one of the top coal importing countries, ranking third after China and Japan. In 2013, India imported a total 180 Mt of hard coal. It has, since 2014, sought to increase domestic production of coal so as to reduce import costs and dependency and produced 724.71 Million tonnes (Mt) of a total requirement of 884.87 Mt. to service industrial needs during the 2016-17 fiscal year A mere 160.16 Mt. was required through imports. India's Minister of State for Coal, Power, Renewable Energy and Mines, Piyush Goyal stated to Parliament in November 2016[19] that the government further plans to become self-sufficient and increase domestic coal production through further forest clearance, land acquisition and coordinated efforts with the railways ministry for movement of coal.

A significant global rise in wind and other renewable energy sources is reflected in an increase from 2% in 2005 to 13.2% in 2015 in India though coal-fired power generation is also on the rise.

The total production of raw coal in India is increasing year on year with production levels for raw coal increasing by 7.7% or from 565.765 Mt. in 2013-14 to 609.179 Mt. in 2014-15. Chhattisgarh notably registered the highest coal production yields at 134.764 Mt (22.12 % of India's total domestic production) followed by Jharkhand at 124.143 Mt. (20.38%) and Odisha at 123.627 Mt. (20.29%). [20]

According to available data,[21] the total production of raw coal in 2015-16 was 639.23 Mt. of which the non-coking variety was 578.35 Mt., as illustrated in Table 3:

Table 3. Production of raw coal during 2015-2016 (Mt).

Sector	Coking	Non-coking	Total coal
Public	54.662	552.016	606.678
Private	6.225	25.331	32.556
All India	60.887	578.347	619.234

Non-Coking varieties of raw coal are predominantly produced by India's public and private sectors for power generation industries. High ash, moisture and sulphur content of coal used to generate electricity make power generation less efficient and more polluting than that produced by industries in the United States and China. SO2 and NOx emissions from coal-fired power plants are also higher in India than that in the US.[22]

Power plants in India, with almost no exceptions, are highly polluting. Given that standards in India are set only for Particulate Matters (PM) and not for other pollutants such as SO2, NOx or heavy metals such as mercury emissions posing risks to the environment and human health are substantially under-reported. The PM standards are also lax and vary from 50 to 350 mg/m3, which is to say, the older the plant, the greater the permitted emissions.[23]

In 2015, the Ministry of Environment, Forest and Climate Change (MoEF&CC) issued notification setting set new emission standards for new thermal power plants requiring a reduction in particulate emissions by 25%, SO2 emissions by 90%, NOx emissions by 70% and mercury emissions by 75%. [See Table 4.]

Table 4. Proposed emission limits for India's thermal power plants under the Environment (Protection) Amendment Rules, 2015 (Bhati and Kanchan, 2015)+

Thermal power plants	Pollutant	Standards, mg/m3
Units installed before Dec 2013*	PM	100
	SO_2	600 (units <500 MW) 200 (units ≥500 MW)
	NOx	600
	Hg	0.03 (units ≥500 MW)
Units installed after 2003 to 31 December 2006*	PM	50
	SO2	200 (units ≥500 MW)
	NOx	300
	Hg	0.03
Units to be installed from 1 January 2017†	PM	30
	SO_2	100
	NOx	100
	Hg	0.03

* The units to meet the limits within two years from date of the notification.

† Includes all the units, which have been accorded environmental clearance and are under construction.

+ Green Rating Project, Centre for Science and Environment (CSE), New Delhi, India - Bhati P, Kanchan Kumar S (2015).

Coal in Chhattisgarh

With over 45% of land surfaces forested and home to a rich array of minerals, Chhattisgarh offers a focus for some of India's richest source of biodiversity. Located at the centre of India, Chhattisgarh is bordered by Uttar Pradesh and Jharkhand in the north, Odisha (Orissa) in the east, Andhra Pradesh in the south, Maharashtra in the south-west, and Madhya Pradesh in the north-west.

The state came into existence on 1 November 2000. Recognising the pivotal role of mineral in the industrialisation of the state, the government of Chhattisgarh has taken a number of policy decisions to eliminate procedural hindrances and to create an environment which allows entrepreneurship to grow expediently and to thrive in this state. The district of Raigarh in Chhattisgarh and its neighbouring district of Korba have huge reserves of coal making it one of the state's primary power hubs.

India's government, ignoring the impact on local populations and the environment, has attracted substantial investments from corporate sectors supporting national and international mining companies to undertake excavations on a massive scale. At the same time, academics, researchers and health professionals to look into the impacts on the populations and environment; social activists to mobilise populations to safeguard their rights; and Maoist political groups to wage war in some parts of the state.

India's 'economic miracle' relies heavily on mining as a source of energy for industrialisation. The states of Chhattishgarh, Jharkhand and Odisha are home to massive reserves of coal, iron, bauxite, precious metals and gemstones, have been exploited since the turn of the century. Rural Adivasi and tribal populations pay a high price for India's growth as their agricultural lands are taken for mining purposes, forests and mountains on which their livelihoods depend on are destroyed, their rivers are polluted or dry up and the air they breathe is filled with poisonous dust and fumes from mining, coal combustion and industries.

Raigarh: coal mining and power plants

Coal has extensively been mined in the Raigarh district of Chhattisgarh since the end of the last century. It has witnessed a growing level of installations of coal washeries, sponge iron plants and coal-fired thermal power stations. The district is currently home to 17 coalmines, 26 sponge iron units and over 13 thermal power stations are either operational or under- construction. [See Table 5.]

Table 5. Coal-fired plants and coalmines in Raigarh district, Chhattisgarh.

Plants/ Mines	Operational	Under construction and/or proposed	Capacity
No of Power Plants	6	7 (3 waiting for environmental clearance)	14,824 MW
No of Mines	7	10	100.27 MT per Annum
No of Washeries	2	6	29.56MT per Annum

Source: Environmental violations in and around coalmines, washeries and thermal power plants of Tamnar and Ghargoda Blocks, Dist. Raigarh, Chhattisgarh – report of a fact-finding team, November 2016.

Mines and plants are destroying the environment and the livelihoods of people living in Raigarh district villages. The Mand, Kurket and Kelo rivers, tributaries of the Mahanadi, flow through Raigarh district which is home to an estimated 21,117 Mt of coal reserves. Mand Raigarh coal reserve, on the basin of river Mand, stretches over several kilometres and has bred coalmines over an area of more than 112,000 hectares.

Gare Pelma coal field in Tamnar and Ghargoda blocks in Mand Raigarh coal reserve are the largest, of 80+ coal blocks and fields spread over an area of 16,649 hectacres. Most coalmines in these two blocks have been sited on agricultural, forest and pasture lands. Villages like Sarasmal, Kosampalli, Libra, Dongamouha, Kodkel in Tamnar Block are within 1-2 KM to coalmines and/or power plants as are Bhengari, Navapara, Charmar, Chhaal in Ghargoda blocks. Villages such as Kosampalli, Sarasmal are less than a kilometer from mining sites. Three villages, Sarasmal, Kosampali and Dongamouha under the Sarasmal Panchayat of Tamnar Block have been examined as part of our study. The combined population of these three villages is around 1,500. All have lost land to the Gare Pelma mine (IV/2,3) and Dongamouha village is directly adjacent to the Dongamouha Captive Power Plant (CPP). Sarasmal and Kosampali are twin villages. Before the onset of mining interests, Kosampalli was directly accessible by roads on all sides but is now cut-off on three sides by surface mining operations. Villagers now have no choice but to cross the river Kelo by foot to access the main road or travel to a nearby market.

Inhabitants of these villages traditionally depend upon agriculture and forestry produce for their livelihoods. The arrival of surface mining operations in their vicinity has significantly affected their agricultural subsistence farming in light of a loss of land, resources and tree felling in local forests.

Some village men have sourced casual work in local mines and power plants. In addition to family caring and household and agricultural responsibilities, women often work as manual labourers in government's employment schemes brought undert the National Rural Employment Guarantee Act of 2005.

Raigarh: Land, River, Forest and Inhabitants

Most local residents are farmers who occupations revolve around subsistence agriculture and forest-based produce. The Mand Raigarh coalfield contains a large number of demarcated coal blocks in dense forest area. These forests play an important role in the life of people living within their bounds as a source of plants for medicinal purposes, animal husbandry and grazing and for timber, fuel, fodder and wood for household and agricultural implements.

Coalmines and associated industries have acquired both forest and agricultural lands, often through unlawful means according to residents in Tamnar and Ghargoda block of Raigarh. Wholesale land acquisition continues. In June 2017, more than 80 Adivasi villagers filed complaints against forceful land acquisition and Amnesty International India have called for investigation into the allegations of dispossession of Adivasi land (https://www.amnesty.org.in/show/news/chhattisgarh-must-investigate-allegations-of-disposession-of-adivasi-land).

Fly ashes from the power plants are dumped in forest plantations and in some cases, on open grounds in violation of legal norms. Waste from the mines and power plants are gradually destroying the forests on which the local people are dependent. Local livelihoods from Tendu leaf collection and Kosa silk production have been severely affected by such pollution.

The river Kelo which runs through Tamnar is highly contaminated by effluents and tailings from the mines of Gare IV/1, IV/2, IV/4 and IV/5. Wastewater stored in mines and ponds is discharged directly into local bodies of water including streams known as nallahs or into the ground. All such waste disposal consequently affects local soil fertility and the quality of local ground water. The Bendra Nallah, for instance, is subject to effluents and tailings from the Gare IV/4 mine, the Karra Nalla from the captive power plant at Dongamouha and its washery - all of which are ultimately discharged into the Kelo river.

In 2016, a two-member team conducted an assessment of the environmental impacts of coalmines, coal washeries and thermal power plants in the Tamnar and Ghargoda blocks of the Raigarh district, Chhattisgarh. The study has documented pollutants in the air, land and water, the depletion of surface and ground water levels. According to the report, *Environmental Violations in and around Coalmines, Washeries and Thermal Power Plants of Tamnar & Gharghoda Blocks, Dist. Raigarh, Chhattisgarh: Report of Fact Finding Team*[24] published in November 2016, severe levels of air, land, surface and ground water pollution by these coalmines, washeries and thermal power plants has led to a loss of livelihood for villagers living in their vicinity. Since the mines opened, the ground water level in over 100 villages in Tamnar has fallen by up to 100 feet and in about 40 villages, the water table has dropped by up to 150 feet.

The study

Purpose of the Study

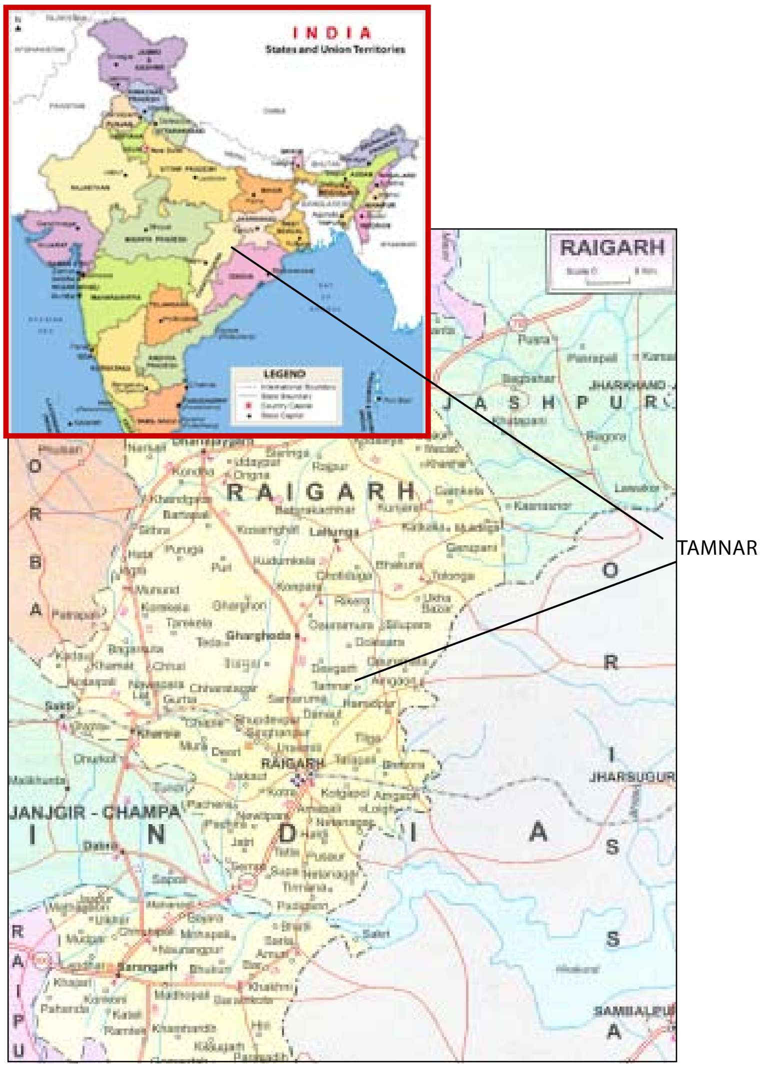
The detrimental health effects of pollutants due to coal mining and its end-use, notably in coal-fired power stations, have been documented in a range of studies detailed earlier in this reports. The socio-economically and health of rural, Adivasi and tribal inhabitants living in the vicinity of coalmines and associated industries are clearly adversely affected by mining. Further investigation is still required to fully ascertain the true impact of mining on the health, environmental, social and economic, on affected populations, forests, biodiversity, wildlife and mammals.

The purpose of *Health and Environmental Impact of Coal Mining in Chhattisgarh* is to consider the nature of major pollutants from coal surface mining, its combustion and disposal of gaseous and solid materials and assess their short and longer-term detrimental health impacts on traditional populations living nearby.

This research study was conducted amongst communities living directly adjacent or close to coalmines and coal-fired power plants in the Tamnar block of the Raigarh district, Chhattisgarh to explore key questions detailed below:
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?

Study Design, Sites and Sample Population

Health and Environmental Impact of Coal Mining in Chhattisgarh is comprised three inter-dependent studies comprised of a) a house-to-house survey documenting self-reported health complaints raised by residents of villages living in close proximity of coal mining or processing plants as detailed in the appendix of this report; b) follow up medical examinations undertaken by a team of qualified and experienced medical doctors to ascertain the health profiles of residents interviewed and consider a fuller diagnosis of their reported health complaints; c) soil sampling of air, water, soil, fly ash and sediment pollutants emanating from coal mining and processing operations in the vicinity of villagers to determine the nature of pollutants to which they might be exposed.



Our field research was conducted amongst villagers who are long-term residents of the Sarasmal, Kosampali and Dongamouha villages in the Tamnar Block of the district of Raigarh, Chhattisgarh. All live adjacent to, or within a maximum 2 KM distance from coalmine and coal-fired power plants.

The study has observed and maintained a good standard of research protocols including approval of our proposed survey protocols and tools by the SHRC Institution Ethical Committee, Raipur (Chhattisgarh), training of interviewers in good practices for community-based survey contact, endorsement and support[1] from relevant state and district authorities. Medical data were collated by staff and statiscians in Durbar, Kolkata and good standards of procedures were maintained in the collection of environmental samples and were tested at well-equipped and international-recognised laboratories including Chester LabNet (www.chesterlab.net), based in Seattle, Oregon, USA.

Data Collection and Methodology

A house-to-house survey was conducted to collect demographics and health information of people living within a kilometre radius of surface coal mining and coal-fired power stations examined as part of this study for a minimum period of five years. While all long-term Sarasmal households present at the time of surveys and medical examinations undertaken between 22nd and 24th of May, 2017, resource constraints limited our survey in Kusampali to every third household and in Dongamouha, every fifth household. The findings of self-reported health complaints and medical examination records for residents of Sarasmal are therefore presented in more detail than the other two villages surveyed as part of this study.

Our research focuses on the health profiles of long-term residents living in close proximity to coalmines and power plants rather than amongst miners or power plant workers. As a comprehensive study of health impacts of residents who work in mines and plants would require substantial further tracking of ill migrant workers, where local village residents are themselves temporary migrant workers they have not been included in our research survey as they typically would return to their own villages if in need of medical treatment or care. In addition to demographics and health information, samples of air, soil, sediment and water were collected from relevant locations of the above villages, surrounding streams, ponds and roadside fly-ash landfills.

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

House-to-house Survey

With prior consent from residents contacted by local community-led organisations, house-to-house surveys were conducted using a set of structured questionnaires. Health survey questions included questions about symptoms related to respiratory, cardiovascular, musculoskeletal, neurological, gastrointestinal, skin and similar contact related complaints. Respondents were also asked if they had been diagnosed with heart disease, stroke, hypertension, diabetes, kidney diseases, chronic obstructive pulmonary disease (COPD) or asthma. The survey also sought to establish a profile of local village demographics,repondents' 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

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

working in coal mines or coal-fired power plants and thereby any additional exposure to coal dust and toxic chemicals. It also explored each household's land yields, household and animal husbandry assets. A total of 515 individuals or 132 households – 82 in Sarasmal, 27 in Kosampali and 23 in Dongamauha – participated in the door-to-door household survey element of this study.

Medical Examinations

A team of medical doctors including a public health specialist, a general practitioner, a gynaecologist and a psychiatrist examined patients from the villages of Sarasmal, Kosmapali and Dongamouha. A temporary clinic was set up for the purpose and prior arrangements were made with the state and district health authorities so that patients in need of further examination could be referred on to the state or district hospitals. Findings from these examinations were recorded on a standard medical form providing notes for respiratory, cardio-vascular, musculoskeletal, skin, gynaecological and other diseases detected in the course of this study. A total of 205 adults and children from Sarasmal (78), Kosampali (39) and Dongamauha (88) attended our temporary field clinics between 22nd and 24th of May, 2017 for further examinations of self-reported health complaints.

Soil, Sediment and Water Sampling

A total of 28 samples detailed in Annex 2 - four air

samples, seven water samples, nine soil samples, two fly ash and six sediment samples - were collected from the villages of Sarasmal, Kosampali, upper and lower Regaon, Dongamauha, Kodkel, Dhaurabhata and surrounding pasture lands. Further information is available in Annex 2 on the nature of samples, their locations and proximities to local mines or power plants or coal washeries.

Air samples were collected continuously over a period of 24 hours from the rooftops of houses in Kosumpali, Sarasmal, Dongamouha and Sakta Sitapur located downwind of suspected pollution sources on days with clear and normal weather devoid of heavy and gusty wind. All samples were sent for analysis to Chester LabNet (www.chesterlab.net), a laboratory based in Oregon, USA.

Water samples from ponds and streams collected for testing were sourced at the Karra Nala stream which flows next to Sarasmal and Kosmapali villages before joining the river Kelo. Karra Nala carries water from a coal washery of the Jindal Power Plant and is used

by villagers for irrigation purposes.
Stream and water samples were also taken from a pond at Kunjemura used for drinking and washing purposes by villages, from the nearby upper Regaon village which is also located 400 meters North of Jindal Power Plant's fly-ash pond.

Soil samples were collected from private lands predominantly used as rice paddies located near to JPL's fly ash pond and coalmines. At the time of our study, team members observed flakes of fly ash dropping on the field and crops where samples were taken.

Sediment from a water stream near the village of Regaon was also collected – the stream leaked from the ash pond of JPL. Several such water streams were found to have formed due to such leakages. Water from these streams meet the local canal and eventually the river Kelo. Similarly the sediment of Bendra Nala that flows from Dongamouha power plant has been collected for testing. The water is used for irrigation, washing and other household purposes.

Soil sample from private land in Kosampali was collected for analyses as were samples of fly ash regularly generated, then dumped in the vicinity of the village of Kosampali by the Tamnar Power Plant. Fly ash dumped on the roadsides of this area were also sampled and taken for testing. Local residents complained that fly ash from the JPL power plant is also dumped all around the village. We have also collected samples of soil from private lands within 100 meters of the JPL fly ash pond.

Analysis

Residents interviewed were restricted to those residing within a 1-2 kilometre radius of surface coalmines and coal-fired power plants. All are therefore likely to have come into contact with pollutants from mining activities through inhalation, ingestion or direct contact leading to induced health problems due to mining and power generation.

We have gathered three sets of information – firstly, self-reported health complaints; secondly, demographic, socio-economic and other variables that may influence the health status of interviewees; and, thirdly, pollutants that may influenced the health conditions of the populations. A fourth data set of medical records was also compiled on the basis of 205 residents attended medical examinations at a temporary clinic established to further investigate self-reported medical conditions.

We have analysed the above information in the light of

- the prevalence of self-reported health problems further explored and validated by clinical examinations;
- a disproportionate prevalence of chronic health complaints including complaints affecting more than one member in a family with same or similar health complaints and more than one anatomical systems;
- the role of variables such as age, socio-economy, nutritional status and so forth to specific health complaints; and
- the nature and extent of pollutants to which long-term local residents are exposed and their impact on their health.

Results


Current complaints:
GYNAECOLOGICAL
Miscarriage / Abortion
SIGNATURE OF DOCTOR

Results

The findings of this study are broadly described in two sections – a health assessments of villagers from participating areas depicting their health profiles, and clinical profiles of self-reported health complaints highlighted in surveys. An environmental element of this study further sampled and tested for the presence of pollutants in air, water, soil, sediment and fly ash samples. Villagers from Sarasmal, Kosampali and Dongamouha which lie within 1-2 kilometres of coalmines or coal-fired power plants participated in the study and were further examined by medical doctors in a temporary medical clinic.

While all Sarasmal households present at the time of surveys during the month of May 2017 and medical examinations undertaken between 22nd and 24th May were visited, resource constraints limited our survey in Kosampali to every third household and in Dongamouha, every fifth household. The findings of self-reported health complaints and medical examination records for residents of Sarasmal are therefore presented in more detail than the other two villages surveyed as part of this study.

Participants

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 Kosampali and Dongamouha are summarised in Table 6.

Demographics, agriculture and other occupation

Villagers surveyed were primarily, if not entirely, composed of indigenous Adviasi people who are classified by the Indian government as being of Scheduled Tribes (STs), Scheduled Castes (SCs) or Other Backward Castes (OBCs).

The population of Sarasmal was entirely composed of STs, SCs and/or OBCs with 68% of residents identifying themselves as being of indigenous Adivasi heritage. A proportion of residents in all three villages are also migrant workers who were not considered in this study because of the temporary nature of their local residence.

Demographics & 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.
- One third of the population are under-weight. In Sarasmal, of the 329 participants (non-record – 12) 113 individuas i.e. 34% are with below normal BMI.
- Most people use ponds and streams for bathing and other household usages.
- Despite the fact that the population live in the midst of coal mines, only a small proportion of households use coal; majority use natural fuel - firewood or cow dung.

Long-term local inhabitants are agriculturally-dependent. In the wake of extensive mining and installations of coal-fired power plants locally, particularly since 2002, crop yield has dropped considerably and residents have sought alternative sources of earnings. Some men are casually employed as manual labourers in coalmines, power plants or with road or bridge construction teams. Others, including women, have also joined local government rural employment schemes.

Of a total of 82 households in Sarasmal village, 45% no longer depend upon agriculture because of low crop yields which now typically provide food for under three months of the year. The picture is similar in the villages of Kosampali and even more grim in Dongamouha where 78% of respondents spoke of unsustainably low crop yields.

Economic and Nutritional Status

34 of the total 82 households in the village of Sarasmal, a total of 41.5% of inhabitants, have low or just manageable assets while 45% possess what is deemed to be 'good' assets according to criteria set at the outset of this study.

At 51%, more than half of village households are without or have few farm animals such as cows, bullocks or buffaloes. Half of the village population struggles to survive while the rest benefit from manageable non-consumable resources earned through manual work or other means. These findings are similar in the other two villages.

The nutritional status of the respondents, reflected in BMIs, however, is a cause of concern and requires further looking into, as highlighted in the 'Discussion' section of this report. On average, one-third of the respondents in all three villages are under-weight. In Sarasmal, of 329 respondents, 113 individuals or 34% of villagers are below recommended 18.5 BMI indicators i.e. under-weight. Only 8% of total respondents in Sarasmal are children under 5 years of age. In other words a significant proportion of adults comprise the under-weight group indicating adult populations lack adequate nutritious food or suffer from chronic illnesses.

Water Sources and Usage

Water usages for drinking and other purposes namely bathing are consistent in all three villages surveyed. For drinking purposes, most residents source water from underground tube wells or shallow wells – and in the case of Dongamouha, by bore well – while surface water from ponds and streams are commonly accessed for bathing, washing and domestic purposes.

In Sarasmal 78% of total households use shallow wells or tube-wells for drinking purposes while 6% use ponds or river streams. 59% of households also use ponds, river or streams for bathing, washing and domestic conerns.

While water samples from Sarasmal and surrounding villages report a dangerously high levels of contaminants of surface water in pond, rivers and streams, the contamination of shallow underground water cannot be ruled out from contamination of soil and surface waters. The use of such water is likely to have adverse effects on human health.

Cooking Fuel Usage

Our study considered the usage of coal as cooking fuel with a view to understanding whether an inhalation of smoke from domestic coal use might have additional adverse effect on the health of household members. In spite of villagers live in the midst of coal mines, only a small proportion of those interviewed use coal for cooking - a majority use natural fuel in the form of firewood or cow dung instead.

In Sarasmal of 77 households interviewed when excluding 5 non-respondent households, only 5 families or 6.5%) of village households use coal for cooking. 47 families or 61% of households used bio-fuel for cooking and the remaining 25 familes used coal and/or gas and firewood. Similar patterns of cooking-fuel consumption were noted in the other two villages surveyed.

Table 6. 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.			

Health complaints

This study has reviewed both self-reported and medically examined and recorded health issues experienced by residents living within a 1-2 kilometre of coal mining operations. Information was collected by trained interviewers delivering a set survey of health questionnaires derived from the scoping and experience of earlier studies undertaken in the USA and UK to record health-related complaints among population living close to coalmines and coal-fired power plants. The health questionnaire was based on health complaints related to respiratory, cardiovascular, musculoskeletal, contact-induced skin, eye and hair conditions, ingestion linked to digestive and kidney complaints proved to be commonplace in all such studies. Self-reported complaints were later validated through full medical examinations undertaken by a team of medical doctors in a temporary clinic.

In addition to a prevalence of mental health related problems, a prevalence of tuberculosis and diabetes which did not form part of the remit of this study were also noted.

Ten self-reported chronic health conditions prevalent among residents interviewed include hair loss and brittle hair; musculoskeletal joint pain, body ache and backache; dry, itchy and/or discoloured skin and cracked sole, and dry cough complaints.

Women predominantly experienced these chronic health problems of which dry cough (77%), hair loss (76%) and musculoskeletal/joint pain (68%) were most prevalent.

Kidney-related health issues and diabetes were frequently reported but, in the absence of substantiating diagnostic information, could not be adequately explored. Mental illness and disability also appeared to be prevalent, and have been confirmed by a psychiatrist joining our medical team but time and resource constraints meant we were unable to fully investigate these self-reported cases in a temporary, make-shift clinic. Further study of these demographic factors is recommended for a better understanding of the source and nature of chronically poor health developments.

12 cases of Tuberculosis (TB) were identified amongst Sarasmal's 341 respondents where respondents were currently or had recently completed treatment. The prevalence of this disease also requires further investigating as a much higher incidence of hidden TB and/or silicosis conditions might be prevalent due to environmental reasons.

Table 7 provides a summary of self-reported health complaints in Sarasmal later confirmed by a team of medical doctors. [Also see Chart 1.]

Table 7. Major health complaints (self-reported) in Sarasmal village.

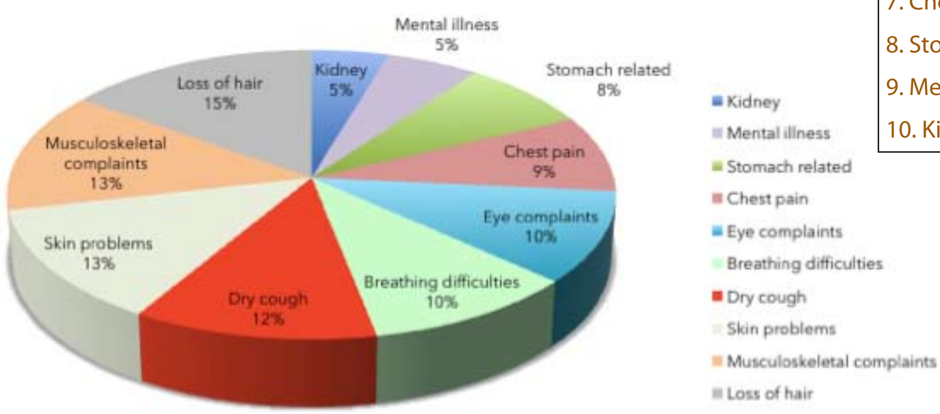
SL	Prevalence of health complaints in Sarasmal.	Number of individuals with specific complaints.				
		Male	Female	Total	% Female	% Total
1	Loss of Hair	27	88	115	76	34
2	Musculoskeletal	33	70	103	68	30
3	Skin complaints	40	60	100	60	29
4	Dry cough	19	71	90	77	26
5	Breathing difficulties	26	52	78	67	23
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

Total households: 82; No of individuals responded to health questionnaire: 341; Total population: 450 (aprox.)
No of individuals screened by a medical team: 78;

* reported by the respondents - not verified with investigation results.

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%

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



Pollutants (Particulate matters and other heavy metals)

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.

A total of 12 toxic metals including including aluminium, arsenic, antimony, boron, cadmium, chromium, lead, manganese, nickel, selenium, vanadium and zinc were found in the water, soil and sediment samples taken around the region. Of 12 toxic metals, two – arsenic and cadmium - are carcinogens while a further two, lead and nickel, are suspected carcinogens.

Pollutants found in air, water, soil, fly ash and sediment samples are summarised in Table 8. Further information is also available in 'POISONED', an in-depth study produced by the 'Community Health Monitoring Group' which can be made available on request.

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

Table 8. An overview of the pollutants found in air, water, soil, fly ash and sediment samples.

No	Sample	No of samples	Analysed for	Results
1	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.
2	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.
3	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.
4	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.
5	Sediment	6	Arsenic; Cadmium; Chromium; Lead; and, Zinc.	Chromium found in all samples; Arsenic, Cadmium in most samples and are exceed the permissible levels.

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.

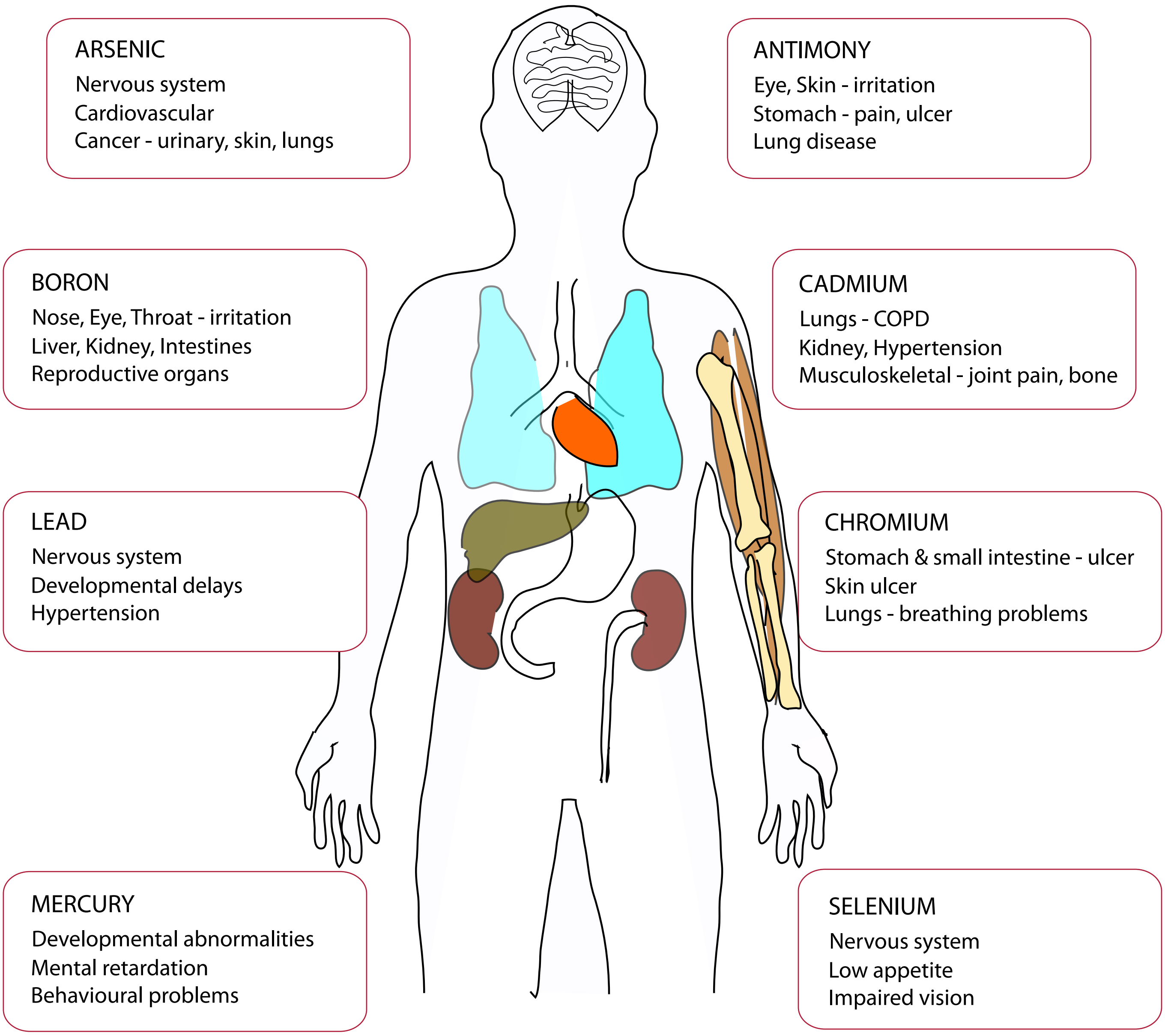
MERCURY

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.



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 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.

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Annexes

Annex 1. 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 (PFCI) brings together professionals, environmentalists and social activists deeply concerned at evidence of complete disregarding for human rights and the destruction of our natural environment in the wake of India's economic 'miracle'. For as long as current indiscriminate mining and industrial practices inflict irreparable damage to the land and natural resources on which Dalit and Adivasi people have dwelt for generations, PFCI will continue to undertake social research, investigate and highlight violations of environmental norms, environmental health and the basic human and land rights of India's most disenfranchised people.