

Pollute and Prosper: An Environmental Injustice

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Preface

The authors, Hinesh Mehta and Samir Gandhi, provide concerned stakeholders with information on the background, current situation, analysis, implications and recommendations associated with illegal levels of industrial effluent from a pulp and paper manufacturing plant owned and operated by Shakumbhri Straw Products Limited (SSPL) in the district of Moradabad, Uttar Pradesh, India. This is not a definitive study due to the nature and scale of pollution.

This report should be read with the following reservations in mind:

there has been no involvement from the polluter, Shakumbhri Straw Products Limited, in compiling the facts of this report;

there has been limited scope to identify the practices used by the polluter to manufacture its end products;

there has been limited scope to identify the practices used by the polluter to manage waste, except that by observation it is evident that little or nothing has been done to reduce contamination.

Executive Summary

The village of Amarpurkashi is located in Uttar Pradesh, Northern India, and has a population of approximately 3000. In 1995 Shakumbhari Straw Products Ltd (SSPL) opened a paper mill near the village, initially bringing jobs and much needed money to the area. However, the benefits were short-lived. A lack of environmental regulation combined with greed and corruption has led SSPL to negate its environmental and social role in society. It is a scenario that is all too familiar in India.

In 1995 a pollution campaign against SSPL paper mill was organised, following the commencement of the mill's operations at Amarpurkashi. This report introduces the campaign with a brief documentary timeline to date. Since the campaign's launch, SSPL's environmental negligence has clearly escalated, inexcusably contaminating the nearby environment. The effect on local communities (with an approximate population of 12,000 in 8 surrounding villages), the local environment, and the economy has been devastating. The campaign has given rise to several *dharna* – protests such as sit-ins and hunger strikes – staged by affected local communities. These have been afforded much publicity in several newspapers and have even given rise to government-led evaluation committees and subsequent reports assessing the pollution and the environmental negligence of SSPL. Despite this, the mill continues to use the Aril River as a dumping ground for its waste effluent, as well as depositing solid waste by the roadside and on farmland for miles around. Little legal or political action has been taken.

Evidence of the contamination is presented in the report according to the range of research methodologies used whilst in the field. Qualitative evidence is first provided through observations that give an indication of the extent of the pollution, observed as air, river and noise pollution. These are supported by telling photographs that clearly illustrate the environmental negligence of SSPL's operations. The impacts of the pollution on local communities are borne out through interviews. A farmer tells of his growing struggle against the ever present pollution – his annual crop yields have fallen by 50% since the arrival of the mill. A local village chief provides a vivid account of the social and health implications of the pollution, and the worsening conditions for local families and their livestock. A visiting nurse combines her professional experience with her observations to give stark warnings that the health problems currently suffered by local communities, including water-borne problems such as jaundice and diarrhoea, breathing problems such as bronchitis and others such as burns and eye defects will only worsen. The list of casualties suffered to date since the mill's arrival are fully documented, the causes of which are strongly suspected to be directly linked to the pollution.

Various recommendations have been made to take the campaign forward. Most notably, the report encourages further and more specific forms of testing to accurately establish the extent of and the potential threats posed by the pollution, in order to reliably assess the risks posed to local communities and the environment.

The report provides quantitative evidence generated from water tests of samples taken from the Aril River. A comparison of various water testing indicators over the eight years up until April 2010 highlights, firstly, the true extent of river contamination, and secondly the change (of clear deterioration of river quality) over time:

- The biological oxygen demand (BOD – an indicator of the water's ability to sustain life) is dangerously high, comparable to raw sewage. The Environmental Agency stipulates that a river of reasonable quality should have a BOD of less than 8.55mg/l. At the site where SSPL discharges its effluent into the Aril River, the BOD is 6150mg/l – more than 700 times the recommended maximum.
- The optimum pH of river water is approximately 7.4, and typically remains between 6.5 and 8.5. Either side of this indicates that the water is unfit for human use. Tests show the pH to average 10.1 at the three sites along the Aril, and as high as 10.8 at Shakhumbhri. This poses obvious risks to human activities such as agriculture and drinking supplies.
- High concentrations of suspended solids can lower water quality by absorbing light, and are an indicator of materials, organic and inorganic, that are suspended in the water, including silt, plankton and industrial wastes. Such an undesirable scenario is proven to be the case with a total suspended solids (TSS) figure of 3870mg/l at Shakumbhari in 2010.

The wider implications of the pollution are assessed in detail in the next section, with potential health, economic and environmental risks and implications presented. However, the risks presented by pollution from SSPL depend on the extent and spread of contamination, and the potential threat to local people. Therefore the report encourages further and more specific forms of testing to more accurately assess this risk. There is a desperate need for accurate, conclusive evidence that undeniably links the pollution to the vast problems detailed in this report. Only then will more attention, in political, legal and public spheres, be afforded to a problem that urgently needs to be resolved.

Aril River Pollution Report

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Aril River Pollution Report

1. Background

1.1 Location

The village of Amarpurkashi, in the North Indian state of Uttar Pradesh, is home to around 3000 people. The village boasts a good range of amenities, including four primary schools, two high schools, a degree college, a health clinic, shops selling everyday items and a twice-weekly market that attracts crowds from neighbouring communities. The surrounding area (which encompasses 8 villages) has an approximate population of 12,000.

The sketch map in 1.1.1 shows the area covered by this report. Shakumbhari Straw Products Limited (SSPL) owns a factory approximately 1km south of Amarpurkashi. This pulp and paper manufacturing unit is the primary source of air, water, land and noise pollution. Nearby, a much smaller pulp and paper manufacturer, Ramchandra, contributes to the pollution problem. The area affected is located near the towns of Bilari and Chandausi in the district of Moradabad. The villages most affected by the pollution are Amarpurkashi, Devri, Dinaura and Vijaypur.

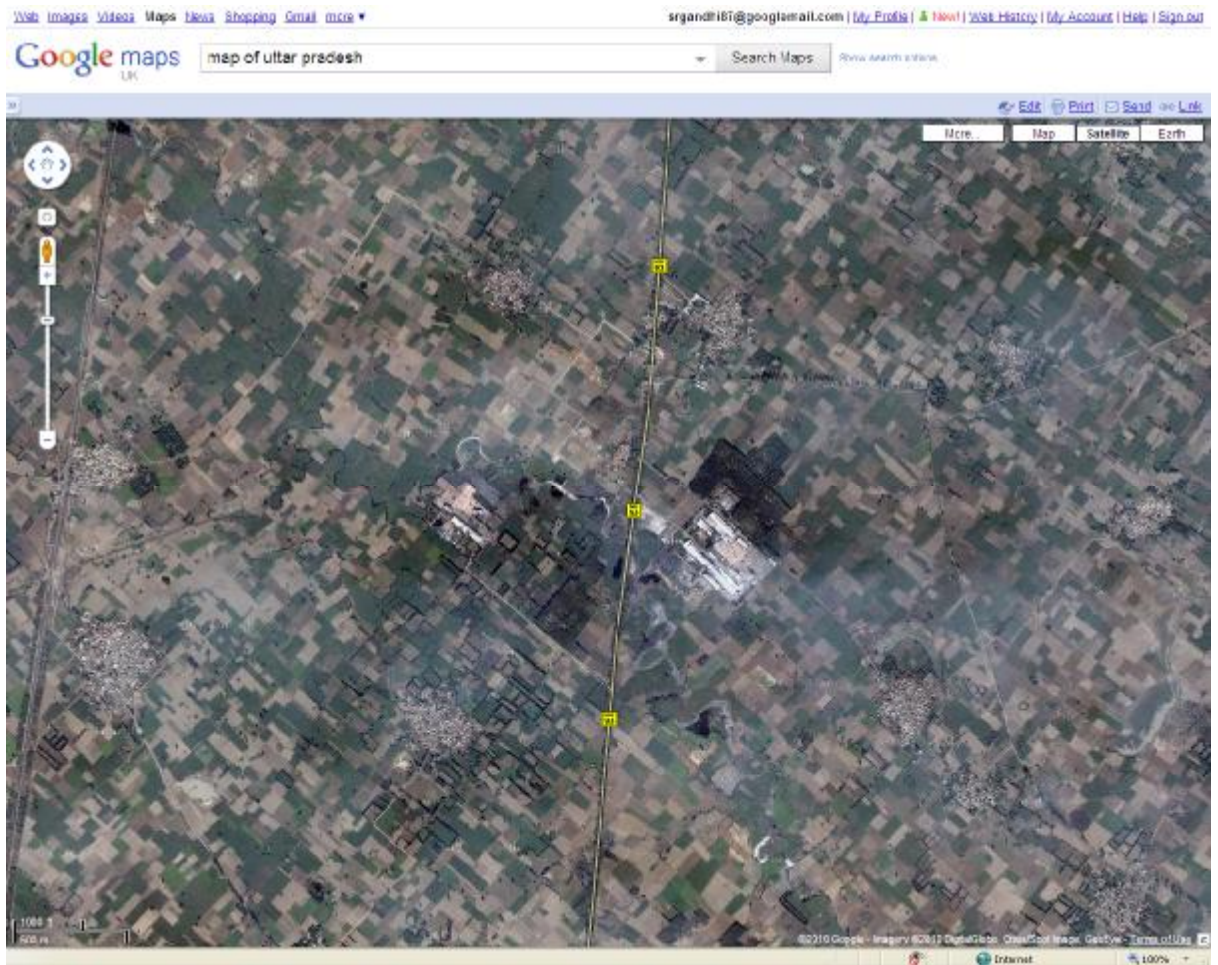
Black ash particles pollute the air around the chimney stacks of the plant, before settling in the area indicated on the sketch map by a red line.

This area includes the Aril River. The river is not the only source of water locally. Waste from the plant flows directly into the river.

The plant was built on agricultural land, and therefore the surrounding land not owned by SSPL is still used by individuals and families for agricultural purposes, providing food and income to local people.

Sound pollution affects the immediate area around the plant which includes agricultural land, homes, small shops, education and health facilities. The link roads used by the plant for transportation affect a wider area.

1.1.1 Sketch map of affected area



1.2 Stakeholders

1.2.1 Environmentalists

Retired civil and environmental superintendent engineer, S.C. Atri, first noticed the pollution after a visit to Amarpurkashi in 1995. He observed black ash particles settling on vegetation around the plant. He carried out a comprehensive investigation and sent a detailed complaint to local authorities.

1.2.2 Local people

Since 1995, local villagers who farm land adjacent to the river and factory have seen their crops ruined, their land encroached on and the water and air that they drink and breathe increasingly polluted. Over the years, groups of farmers have protested outside the factory gates, gone on hunger strike and handed in numerous complaints to the *tehsil diwas* (public hearing days).

1.2.3 Indian Volunteers Community Scheme (IVCS)

Through its "Experience India" scheme, IVCS has sent many overseas visitors to Amarpurkashi. They have all felt the effects of the polluted air and the granular ash that settles on their clothes, hair, skin and eyes. They have seen the terrible state of the River Aril and have had to endure the appalling stench of the factory effluents.

1.2.4 Asian Foundation for Philanthropy (AFP)

AFP became involved in this campaign after witnessing the pollution on a field visit. After hearing about the hunger strikes, health problems and overall effect on the local area, AFP has supported the campaign with several events in the UK highlighting the issues, sending volunteers to monitor and evaluate the effects of pollution and requesting a filmmaker to capture the changes at village level.

1.2.5 Shakumbhri Straw Products Ltd.

There has been no involvement of any kind in the pollution campaign from the polluters themselves. All dialogue has been in a single direction with no direct response from the factory owners.

1.2.6 Government of Uttar Pradesh

The State Government of Uttar Pradesh has had very little involvement in addressing pollution from the pulp and paper manufacturing plant operated by SSPL. Aside from continuously ignoring correspondence from concerned stakeholders, a task force was set up in 2005 in response to a protest by agricultural workers.

Concerned stakeholders in the international community are continuing to work with those affected by the pollution to achieve a positive outcome for all.

1.3 Timeline

The following timeline is a summary of the campaign to date which has aimed to mitigate pollution of the manufacture of pulp and paper from Shakumbhri Straw Products Limited:

26/12/1995	Shri SC Atri, a retired civil and environmental superintendent engineer, carried out a comprehensive survey and prepared a detailed complaint which was sent to the Governor of Uttar Pradesh, the Chief Minister of UP, the State Pollution Control Board of UP, and the Minister of Environment and Forests, the Government of India, New Delhi.
16/04/1996	Mr Atri sent reminders to all the above officers.
16/04/1996	Daily Newspaper Amar Ujala published a detailed news article about the complaint raised by Mr Atri.

05/04/2002	Testing of four samples of water along the Aril River carried out.
22/02/2002	A workshop with local people, teachers and other concerned stakeholders was also held to discuss the problem of increasing pollution in the area. Daily newspaper, Amar Ujala, Moradabad, gave a full coverage of the complaints and recommendations.

Nov 2005	Aggrieved farmers staged dharna (peaceful sit-ins), and a hunger strike in an attempt to get compensation for their damaged crops. Aggrieved farmers whose crops were ruined by the overflowing polluted water from the Aril River complained and protested on 'Tehsil Diwas' on 16/11/2005, 20/11/2005, 30/11/2005
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Consequently, a committee was appointed to assess the damage to the crops. It was headed by the *Tehsildar* (Revenue Officer) of Bilari and included farmers' representatives, the regional office of the State Pollution Control Board in Moradabad, representatives from SSPL and Ramchandra Straw Products and other government officers.

12/12/2005	<p>The Evaluation Committee presented its comprehensive report, covering damage to crops by overflow of polluted water to the sub-divisional magistrate of Bilari. The findings included:</p> <ol style="list-style-type: none">1. The treatment plant of waste water from Shakumbhri's unit is unable to treat the waste water because of its low capacity. As a result, effluent from machinery flows into the Aril River, polluting and blocking the flow of water. Waste water is spreading into nearby crops causing considerable damage.2. This waste water is possibly polluting the underground water.3. The treatment plant of waste water from Ramchandra in Vijaypur is similar. The waste water is pouring into the Aril River resulting in further water pollution and causing swamps and overflow.4. A correct evaluation of the capacity of treatment plants should be carried out by an appropriately qualified agency.5. Enquiry and assessment of damage done to the crops of farmers on the other side under Chandausi Tehsil should be carried out with staff and officers of that Tehsil for the record.6. The report includes a list of assessment of damage to the crops of farmers from Vijaypur, Devri, Amarpurkashi and Shamaspur. <hr/>
25/01/2006	<p>Aggrieved farmers protested again and demanded compensation, but the sub-divisional magistrate flatly refused to take any action.</p>
04/09/2006	<p>Complaints of the SDM's refusal to take any action and to help the farmers were made to the district magistrate in Moradabad.</p>
28/11/2006	<p>On behalf of the aggrieved farmers, the Society for Agro-Industrial Education in India appealed to the district magistrate and the regional office of the State Pollution Control Board, to take action on Tehsildar Bilari's report. No response.</p> <hr/>
07/02/2007	<p>Under the Right to Information (RTI) Act, a legal request for obtaining copies of the Tehsildar's report, and actions and decisions taken on the court cases pending in the SDM Court against the polluting factories, was made to the Public Information Officer, Tehsil Bilari.</p>
14/03/2007	<p>Under the RTI Act, a first legal appeal was made to the sub-divisional magistrate (SDM) Bilari against the Public Information Officer, who failed to respond to the legal request.</p>
21/04/2007	<p>A second appeal under the RTI Act was sent to the State Public Officer in the state</p>

capital, Lucknow.

29/08/2007 A reminder of the appeal to the State Public Information Officer was sent. No response received.

29/10/2007 Letter No. 24445/5-10/General

To Shri Mukat Singh, General Secretary, Society for Agro-Industrial Education in India, Amarpurkashi, Bilari, Moradabad.

Re: Demands of the third day of 'Sanketik Dharma' on 23/09/2007

Please refer to your Letter No. 10274/ DH/2007 dated 24/09/2007. In this connection it is to be informed that the District Magistrate has appointed a Task Force Committee under the Chairmanship of the Chief Development Officer for the Solution of the problem of water logging and water overflowing of the Aril River. Your problems will be solved according to the rules.

Sd. Regional Officer

24/10/2008 A letter of demands was passed in the third session of the State Convention of the National Alliance of the People's Campaigns held in Amarpurkashi. Demands were addressed to the District Administration and the Regional Office of the State Pollution Control Board, Moradabad.

1. Promises given by the sub-divisional magistrate of Bilari on 26/02/2008 to a public meeting, and the six points of demands and suggestions submitted to him on 12/12/2008, must be fulfilled within the next 20 days.

2. SDM of Bilari must arrange payment.

16/07/2008 Asian Foundation for Philanthropy (AFP), together with Mr Mukat Singh and Mrs Jyoti Singh, held an event in London, "Pollute and Prosper: At What Cost?", to raise awareness about the issues at hand and to mobilise the Asian diaspora. Attendees wrote letters to key politicians in India to voice their concern about the issues.

2009 Asian Foundation for Philanthropy sent a filmmaker to capture the changes happening at the village level and continued support by encouraging dialogue through events in the UK

October 2009 Second testing of four samples of water carried out.

13/10/2009 A stall at the annual Amarpurkashi Science Fair aimed to educate local people about the pollution issues affecting the area.

Nov 2009 30 handwritten and typed letters posted, and 30 emails sent by volunteers from AFP and IVCS to politicians at district and state level. No response.

2. Observations and perceptions

A period of two months was spent in the affected area between October and December 2009. The following observations and perceptions were collated in that time from the authors, local people and other concerned stakeholders.

2.1 Processes

The process of pulping (removing lignin from wood), and the manufacture of paper (and other paper products), requires a range of chemicals. Fillers, additives, biocides, bleaches, sizes, barriers, coatings, and dyes are used, as well as chemicals listed in the Annex. Transporting these materials creates a significant risk of spillage. Pulping is a water-intensive process. High pressure jets are used to de-bark logs of wood. The resulting chips are washed to remove particles, before the pulp is cleaned with water, and then thickened to remove dirty water. After this process, the pulp can be dried for other uses. Information on Shakumbhri's website is not clear on what process is used to manufacture paper. It could be inferred that the plant operates using the Kraft process. This involves sodium hydroxide and sodium sulphide, and residual liquor could be deposited illegally into the Aril River. Washing or floatation methods are normally used in the process of removing impurities, and the resultant residue could easily end up in the Aril River, via the direct waste water pipe, or in landfill. Efficient paper mills will recycle large volumes of water, but locating near a good water source is necessary. It is likely that SSPL uses more than 100m³ per tonne of product. Again, incoming water needs to be treated for impurities, and by using water high in total suspended solids (TDS), more chemicals, and more cost is required. If SSPL had an effective effluent treatment process, the need to tap into pure water sources would be reduced. It is possible that with a diminishing water supply SSPL may have to transport water to the plant. This is not an option for people.

2.2 Extent and spread of pollution

There are several sources of effluent with a contamination potential. The sketch map 1.1.1 represents the geographical spread of water, air, and land pollution.

2.2.1 Air pollution

Air emissions are likely to include sulphur dioxide, hydrogen sulphide, and mercaptans (Department of the Environment, 1996). This can be reduced by a process called scrubbing which uses precipitation and oxidation. The black ash emitted from SSPL's smokestacks has settled on vegetation, agricultural land, and onto people. It has had an effect on eyesight, and caused serious respiratory problems (see 2.4.1). The ash is not contained by the plant, and it seems the ash has not been treated either. The smell that arises from the site is unbearable and radiates a large area. Even from travelling through the area on the national highway it is a foul odour that clearly emanates from Shakumbhri's paper mill.

The illegal dumping of waste ash mounds on the roadside and nearby land has resulted in further air pollution. Fine particles of waste ash are carried by the wind and were found to travel considerable distances. Local communities complain of how the ash has wider

implications on everyday life. Even chores such as washing clothes or eating outside have been complicated by falling ash (see Section 2.3.4).

2.2.2 Water pollution

Waste produced as a result of pulping operations has been discharged directly into the Aril River through an approximately 20inch diameter waste water pipe running directly from the plant to the river. The waste contains chemicals used in the process, including bleaching agents and biocides. The waste from pulping has a very high biological oxygen demand (BOD). A dirty-brown liquid that has not been treated flows through the pipe.

Visible pollution in the surface water is coupled with the problem of seriously polluted groundwater. As pollution in groundwater is often invisible, many have suffered the dangerous consequences that are common with using polluted groundwater. Having transuded into the water system, and with the polluting of air, the scale of the local health problem is shocking.

Disposing of sludge and black ash has been a major issue for SSPL. SSPL have, in the past, fooled farmers into believing their ash can be used as fertiliser for their land. Some farmers were even deceived into parting with their hard-earned money in order to get hold of the ash. However, the ash has no nutritional value whatsoever and may cause actual harm to the land. This requires further investigation.

2.2.3 Land pollution

The state of the soil adjacent to the River is solid, dry, and cracked from the layers of black ash that has been deposited. Normally, this land would be ideal for growing sugarcane or rice. However, the harshness of this soil means that farmers have had to resort to growing hardier crops such as mustard-seed (*sharsho*), but which attract lower prices. In particularly bad cases (see 2.3.2) farmers have been unable to grow any crops whatsoever, and have been forced to sacrifice income altogether. Contamination of the land could have resulted from constant landfilling of chemical and organic wastes.

Soil adjacent to the Aril River



Hardier mustard-seed crops growing amongst fragments of ash



2.2.4 Noise pollution

Air, water, and land pollution are visible on the map and in the photos. However, sound pollution is another problem that local people have been forced to endure. Living or working in the area around a twenty-four-hour-a-day, seven-day-a-week industrial unit can have harmful consequences for health. Through discussions with villagers, we learnt that these unwanted noises have caused headaches, migraines and loss of hearing. The constant fleet of heavy goods vehicles transporting material to and from the site brings further sound pollution.

2.3 Interviews

2.3.1 Rameshi, village chief of Amarpurkashi (December 2009)

1. *How have the people of APK been affected by the pollution?*

The whole community has been affected in various ways. More recently it has been noticed that most of the children born suffer from jaundice – some have already died from it. In my family alone two children have recovered from jaundice thanks to expert treatment from a doctor in Chandausi. In another family in the village, a baby only three days old is currently under treatment for jaundice.

2. *Do they understand why pollution is bad for them?*

The villagers see ash all around them falling onto their clothes, their food-stuffs, courtyards and so on. They are therefore aware of the pollution and that it is not a good thing. When they use their hand pumps they see water of a yellowish colour coming out, which is making them alarmed – but they feel powerless and do not know what to do.

3. *What action has been taken by the farmers, and was it successful?*

Quite a few villagers have complained, protested and even staged hunger strikes but nothing has been done in response to this action.

4. *Have any farmers been compensated by Shakumbhri, and if so, how much?*

One farmer has received compensation quite a few times. His name is Hazari. He was first compensated with Rs. 40,000 but I do not know how much he was subsequently compensated. Hazari has the largest farm – more than 4 acres of land in the vicinity of the river and factory. He received compensation for the damage caused to his rice paddy fields, but even then was not fully compensated for his loss. No other farmers have received any compensation.

5. *Is the pollution getting worse over time?*

The pollution is getting worse day by day. The greatest problems arising are due to the polluted water and falling ash. These are affecting farmers in the cultivation and harvesting of their land and the fodder is inedible for the cattle. As the pollution worsens day by day, so will these problems.

6. *How do the monsoon rains affect the pollution?*

If the rains are good, overflow of the Aril River and its pollution will cause harmful water-logging. The affected crops cannot then be cultivated and standing crops will be damaged. So the rains actually bring havoc for these particular farmers.

2.3.2 Jagat Singh, farmer

The following is adapted from an interview conducted in Hindi in December 2009:

- Jagat Singh is thirty years of age, and has been working on the family farm all his life.
- His family owns one hundred bighas (one bigha equals one sixth of an acre) of land adjacent to the Aril River, in which they cultivate sugarcane, rice, millet and mustard-seed.
- During the monsoon season the river overflows and water logs most of his fields, with the polluted water approaching the walls of Shakumbhri (that borders his fields).
- Due to the pollution from the Aril River, he has lost approximately Rs10, 000 in the last three months of 2009.
- The falling ash has resulted in a long term loss of earnings, as poorer quality sugarcane means he earns Rs180 per quintal as opposed to Rs210 per quintal. Furthermore, as the sugarcane in his fields only grows to around 7-8 feet (as opposed to 15 feet for healthy sugarcane) his loss of earnings is greater than 50%.
- He took part in a protest against Shakumbhri, organised by Mukat Singh two years ago. He says that the protest was not successful, and the situation has certainly not improved.
- Five of his buffalo have died as a result of feeding on polluted millet and sugarcane. A further three buffalo have recently suffered from ash in their eyes. They became agitated and gave little milk during the one month it took for their eyes to fully recover, with a cost of Rs50 per buffalo for the necessary medicines.
- He believes that a longer term implication on human health is that the falling ash is contaminating rice grains, and when eaten the ash builds up inside one's digestive system to cause serious health problems.

2.3.3 Sara Allen Sandy, retired nurse and project visitor to the Society for Agro-Industrial Education in India, from Phoenix, Arizona, USA (November 2009)

The following is adapted from an interview conducted during a one month stay in Amarpurkashi:

- The factory is located too close to the village.
- The visible, heavy pollution in the river is clearly the result of the 0.5m sewage pipe that runs directly from the factory to the river.
- The river does not splash like normal water. It is a very thick sludge of sewage.
- The area around the factory is covered in black ash. People are covered in the ash and the ash is also being transported.
- The workers clearly don't realize the impact of the ash on crops and animals.
- The wildlife – birds, cows and vegetation – is all covered in ash.
- The whole cycle of biodiversity is affected.
- There is no way people can live in this environment:
 - The local population has become desensitized to the conditions, adjusting to them.
 - The pollution enters their bodies from the air and through water.
 - Breathing, eating and drinking results in the ash getting into the respiratory system, integumentary system and skin.
 - People don't realize the impact the air pollution has on their mucus membrane.
 - They notice their eyes irritating.
 - There is likely to be some chemical that is fat soluble which affects the liver. It can't pass through the human body in the normal way and instead, builds up. This poisons the liver.
 - Jaundice is a symptom.
- Perhaps they have no choice.

2.3.4 Umesh Kumar, worker in the degree college in Amarpurkashi

"A number of people from this area are facing a range of problems due to the ash which falls from Shakumbhari's paper mill. Just going about our daily routine exposes us to the ash. For example, when we sit to take our meals the ash falls on our food, whilst outdoors ash falls on our hair, our clothes and in our eyes. We have to suffer financially when we are forced to buy medicine when the pollution makes us ill."

Umesh urges that the pollution is stopped immediately, as he insists that these problems will only become worse, and the local people will become increasingly vulnerable, financially and health-wise. He emphasises that the poorest will suffer the most.

2.4 List of casualties (as at December 2009)

A range of health problems have become increasingly apparent since the introduction of the mill to the area. Air pollution has resulted in bronchitis and other breathing-related conditions (for many sufferers their symptoms have as of yet not been diagnosed). Fine particles of ash are carried in the air following the illegal dumping of waste ash material in nearby land. This ash inevitably finds its way into local people's eyes, affecting their vision and in worst-case scenarios even leading to blindness. River pollution is suspected to have resulted in contamination of the groundwater supply, increasing the incidence of water-borne illnesses

such as jaundice and diarrhoea. Section 4.1 provides an indication of the anticipated effects the worsening pollution will have on the health of local communities if current trends continue.

The following lists have been compiled from records kept in the local health centre. The lists are not historical and therefore not definitive. Many more will have suffered from the pollution. Additionally, others will not have come forward with health problems due to fear and embarrassment.

2.4.1 List of casualties (as at December 2009) – Amarpurkashi:

No	Name		Illness (death)
1	Hitindra Singh	s/o Rajpal Singh	Jaundice
2	Parmanand Sharma	s/o Ghan Syam	Jaundice (death)
3	Munnidevi Sharma	w/o Parmanand Sharma	Jaundice (death)
4	Syam Singh	s/o Babu Ram	Both hands and legs burnt by live ash (see Figure 2.4.2)
5	Ram Vati	w/o Suresh Singh Yadav	Jaundice (death)
6	Ram Khilaru	s/o Kham Karan Singh	Jaundice
7	Kamlesh Devi	s/o Rajesh Singh Yadav	Jaundice
8	Ganga Ram	s/o Indramann Singh	Jaundice (death)
9	Pribesh Devi	s/o Jolly Chandra Bashi	Jaundice
10	Nisha	d/o Harpal Singh	Jaundice
11	Vishnu Singh	s/o Subhash Singh	Jaundice
12	Bhagvandas	s/o Ram Ratan Singh	Jaundice
13	Chottu	s/o Jagatpal Singh	Jaundice
14	Pappu Singh	s/o Om Prakash	Jaundice
15	Mohar Singh	s/o Banshisani	Ash in his eyes
16	Ashok Kumar		Jaundice, high blood pressure
17	Lekhni Gupta	d/o Ashok Gupta	Left eye's vision severely impaired

2.4.2 Syam Singh after being burnt by live ash



2.4.3 List of casualties (as at December 2009) – Devri:

No	Name		Illness (death)
1	Ketaki Devi	w/o Baboo Singh	Jaundice (death)
2	Sheela Devi	w/o Guddoo	Jaundice (death)
3	Madan Pal	s/o Natthoo Singh	Jaundice (under treatment)
4	Munni Devi	w/o Indal Singh	Jaundice (death)
5	Gajram	s/o Shyam Singh	Jaundice
6	Mahendra Pal	s/o Pran Singh	Jaundice
7	Atram Singh	s/o Chetram	Jaundice
8	Ashok Pal	s/o Dhoom Singh	Jaundice (under treatment)
9	Dalpat Singh	s/o Jhandoo Singh	Jaundice (under treatment)

10	Sukhdev	s/o Rajvir	Jaundice (under treatment)
11	Veer Pal	s/o Pran Singh	Jaundice
12	Bhoore Singh	s/o Sukhram Singh	Jaundice
13	Heere	s/o Chetram	Jaundice
14	Vijai	s/o Trimal	Lost eye due to fly ash
15	Ajai Pal	s/o Sandan Singh	Lost eye due to fly ash
16	Balvir	s/o Dhakan Singh	Suffered as a result of fly ash in eye
17	Rajvati	w/o Pan Singh	Under treatment for eye as a result of fly ash
18	Shakuntala Devi	w/o Subhash	Under treatment for eye as a result of fly ash
19	Baboo	s/o Saroopi	Legs wounded by live ash
20	Bhoori Devi	w/o Sandan Singh	One eye damaged because of the fly ash
21	Mangli	s/o Rai Singh	One eye damaged because of the fly ash
22	Khoobkaran	s/o Natthoo Singh	Milk buffalo died

2.5 Photo gallery

The following photographs are of the paper mill run by Shakumbhri Straw Products Limited (SSPL), the surrounding area including pollution (air, water, and soil) directly from SSPL, and affected people. The photographs were taken in November 2009.

2.5.1 Shakumbhri's pulp and paper manufacturing plant in the background, and waste pipe in the foreground



2.5.2 Shakumbhri's waste pipe releasing effluent into the Aril River and the splash of a rock being thrown



2.5.3 River bank at Devri



2.5.4 A close-up of the solidified river surface approaching the bridge at Devri



2.5.5 Cattle grazing on the banks of the Aril River, surrounded by mounds of ash



2.5.6 Ash mounds deposited by the Roadside, with Shakumbhri in the background



2.5.7 Unfertile field surrounding the Aril River that cannot support any agriculture



3. Water analysis

Along the Aril River, three samples of water have been tested for contamination. The first test was conducted in April 2002, the second test in November 2009, and the third test in April 2010. For credibility, this report has compared the results of April 2002 and April 2010. This accounts for the impact of the annual monsoon season, from July to August. The 2002 tests were carried out at the People's Science Institute in Dehradun, and the 2010 tests were carried out at the RTC Laboratory in Moradabad.

The tests carried out in November 2009 have been deemed inadequate. The reason for this can be attributed to testing the water very soon after the late monsoon of 2009 instead of testing in the drier season.

Site 1 – Ramchandra paper mill

- There are many ponds, some fairly large, of stagnant water (consisting largely of effluent) beside the river.
- There is some flow at the surface, but not on the riverbank. The flow is inconsistent and has yellowish-green effluent stinks and bubbles.
- The crops immediately beside the river seem healthy, but all the crops close by and further away are covered by a fine layer of ash. The fields that have been left fallow are clearly covered in ash on the surface.

- There is no evidence of wildlife except flies and mosquitoes.

3.1 Water sample locations

Collecting water samples at Site 1



Site 2 – Shakumbhri Straw Products Ltd (SSPL) paper mill

- The river is largely stagnant at the surface, and there is a brown-yellow sludge.
- There are large mounds of ash deposited on one side of river, where cattle are frequently grazing.
- There are many birds on the riverbanks.
- The waste water pipe pours out fairly high volumes of brown-green effluent into the river, what appears to be 24 hours a day.
- There is a layer of fine (sometimes thicker) ash that covers all vegetation in the vicinity of the paper mill.

Site 3 – Aril River (downstream)

- The river water is flowing but there is evidence of brown effluent floating on the surface.
- As the river flow approaches the bridge near Devri, the surface of the water is enveloped by a thick layer of sludgy effluent. Here the floating effluent has built up to form a layered sheet of sludge, which after 5 metres becomes a thicker light brown sludge, and finally after another 2 metres a black-brown, fairly solid layer of ash and stagnant surface effluent.
- This continues for 100 metres or so up until the bridge, where the pollution has built up to such an extent that one is able to step on the river surface without falling through.
- Children aged around 10 years old are seen scouring the rubbish that has deposited on the polluted river surface, and look to be at risk of falling through.

- Land on one side of the riverbank cannot be used for rice or sugarcane due to the ash, so mustard-seed is grown instead. On alternate sides the height of the bank acts as a barrier to river overflow during the monsoon season, and therefore sugarcane can grow without risk.

Site 3 showing Shakumbhri's paper mill in the background with the waste [water pipe releasing sludge into the Aril River in the foreground](#)



3.1.1 Site 3 showing river pollution at Devri



3.2 Analysis of parameters

3.2.1 Results

	Test Date	pH	BOD	TSS
Site 1 – Ramchandra paper mill	Apr-02	9.5	1500	1070
	Apr-10	9.8	4750	2450
Site 2 – Shakumbhri Straw Products Limited	Apr-02	10	2900	1370
	Apr-10	10.8	6150	3870
Site 3 - Aril River (downstream)	Apr-02	9.5	1780	1400
	Apr-10	9.7	3420	2370

Key		Unit
pH	pH Value	
BOD	Biochemical Oxygen Demand	mg/l
TSS	Total Suspended Solids	mg/l

Test Date 1: Apr-02	Test carried out by the People's Science Institute, Dehradun
Test Date 2: Apr-10	Test carried out by RTC Laboratory, Moradabad, UP (Govt. of India)

3.2.2 pH

The pH of river water is a measure of how acidic or basic (or alkaline) the water is on a scale of 0-14. A pH of less than 7 is acidic; a pH of more than 7 basic. The optimum pH for river water is approximately 7.4, whilst extremes in pH of water can make it inappropriate, even dangerous for human purposes (as it becomes inhospitable to life). The pH of freshwater bodies varies from source to source, as it is very much influenced by the eco-system that surrounds the body of water. For example, it can actually be reasonable for a creek to have a pH of 5.5, which may seem highly acidic. Hence it is often more useful to analyse the *change* in pH over time, as an indicator that the local eco-system is being affected in some way.

Furthermore, current water quality regulations in the UK specify that the pH of tap water be between 6.5 and 9.5 (United Utilities, 2010). According to the results the pH increases at all three sites between 2002 and 2010. Initially averaging at 9.67, the pH rises to a highly-alkaline average of 10.1. Change is most extreme at Shakumbhri, increasing in pH by as much as 8% to 10.8. Considering that freshwater typically has a pH of between 6.5 and 8.5, it is no wonder that aquatic life is unable to survive in the Aril at Shakumbhri. Furthermore, a high pH allows microbiological activity to thrive, which helps to explain the high BOD.

3.2.2 Total suspended solids (TSS)

Total suspended solids are materials, organic and inorganic, that are suspended in the water, including silt, plankton and industrial wastes.

High concentrations of suspended solids can lower water quality by absorbing light. Waters then become warmer and lessen the ability of the water to hold oxygen necessary for aquatic life. Because aquatic plants also receive less light, photosynthesis decreases and less oxygen is produced. The combination of warmer water, less light and less oxygen makes it impossible for some forms of life to exist.

Suspended solids affect life in other ways. They can clog fish gills, reduce growth rates, decrease resistance to disease, and prevent egg and larval development. Particles that settle out can smother fish eggs and those of aquatic insects, as well as suffocate newly-hatched larvae. The material that settles also fills the spaces between rocks and makes these microhabitats unsuitable for various aquatic insects, such as mayfly nymphs, stonefly nymphs

and caddis fly larva.

Suspended solids can result from erosion from urban runoff and agricultural land, industrial wastes, bank erosion, bottom feeders (such as carp), algae growth or wastewater discharges.

Table 6.1 shows how the TSS has dramatically increased during the 8-year period between the two tests. Averaging at 1280mg/l in 2002, the TSS more than doubled to an average of 2897mg/l in 2010. Again, the test shows Shakumbhri to be most adversely impacted, with the TSS nearly tripling to 3870mg/l.

In the case of the Aril, the excessive extent of the pollution poured into the river has allowed levels of suspended solids to reach astronomical levels, thereby slowing the movement of the river water downstream. A high TSS therefore contributes to a high BOD, whereas faster flowing bodies of water tend to have a lower BOD, as organic matter is transported downstream more swiftly. The reduced velocity of the Aril's water leaves organic matter more exposed to microorganisms, thus the demand for oxygen is extremely high.

3.2.3 Biological oxygen demand (BOD)

Microorganisms such as bacteria are responsible for decomposing organic waste. When organic matter such as dead plants, leaves, grass clippings, manure, sewage, or even food waste is present in a water supply, the bacteria will begin the process of breaking down this waste. When this happens, much of the available dissolved oxygen is consumed by aerobic bacteria, robbing other aquatic organisms of the oxygen they need to live. This process is called eutrophication.

Biological Oxygen Demand (BOD) is a measure of the oxygen used by microorganisms to decompose this waste. If there is a large quantity of organic waste in the water supply, there will also be a lot of bacteria present working to decompose this waste. In this case, the demand for oxygen will be high (due to all the bacteria) so the BOD level will be high. As the waste is consumed or dispersed through the water, BOD levels will begin to decline.

When BOD levels are high, dissolved oxygen (DO) levels decrease because the oxygen that is available in the water is being consumed by the bacteria. Since less dissolved oxygen is available in the water, fish and other aquatic organisms may not survive.

The Environment Agency in the UK assesses the quality of a river ecosystem (RE) using a clear and established system, based around River Quality Objectives (RQOs). The objectives are determined according to the recognised uses of a river ecosystem in the UK. Here it must be noted that communal uses of the river ecosystem of the Aril River near Amarpurkashi may well vary somewhat. The Environment Agency's RQO Scheme does provide a neat starting point for analysis however.

Classifications for BOD levels of water bodies

Source	Standard mg/l
River Quality Objective – RE1	1.425
River Quality Objective – RE2	2.28
River Quality Objective – RE3	3.42
River Quality Objective – RE4	4.56
River Quality Objective – RE5	8.55

The RQO Scheme stipulates the following categories

Class RE1:	Water of very good quality suitable for all fish species
Class RE2:	Water of good quality suitable for all fish species
Class RE3:	Water of fair quality suitable for all fish species
Class RE4:	Water of fair quality suitable for coarse fish populations
Class RE5:	Water of poor water quality which is likely to limit coarse fish populations

Compliance with these objectives is classed by the Environment Agency as *pass*, *marginal* or *fail*. With a BOD averaging 1280mg/l in 2002 and rising to an average of 2897mg/l in 2010 at the three sites along the Aril River, BOD levels in the Aril River would undoubtedly *fail* according to the Environment Agency's RQO Scheme.

Various other sources indicate that:

- Pristine rivers will have a BOD of <1mg/l
- Moderately polluted rivers will have a BOD of 2-8mg/l
- Efficiently treated sewage will have a BOD of <20mg/l, and
- Untreated sewage typically will have a BOD of approximately 600mg/l, depending on the content of the sewage.

According to this classification the polluted river water of the Aril River is more comparable to sewage than to river water, and is in fact of poorer quality than untreated sewage.

The remarkable degree to which BOD is high can possibly be explained by the nature of the pollution dumped in the river. If the pollution has a high organic matter composition, for example from wood fibre, the pollution will have a high BOD due to high microbiological activity.

4. Potential implications

4.1 Health

This report documents a total of thirty nine people with health problems that can reasonably be linked to the pollution produced by Shakumbhri's paper mill. Seven have died having displayed symptoms of jaundice. After drinking from the contaminated water supply, harmful chemicals are likely to have built up in their bodies. This has resulted in liver poisoning, jaundice and potentially death. As the level of pollution increases over time, water contamination will increase, and consequently the incidence of liver-related health problems will inevitably increase over time.

Animal welfare will suffer as the quantity of ash in the air rises. Milking buffalos is a sensitive activity and this will be affected as the animals suffer from ash in their eyes, or when the fodder they eat becomes contaminated. The pollution has already resulted in the death of many buffalos in the local area. Many more are suffering from ash in their eyes. As pollution levels increase, the health of vital animals such as buffalos will inevitably deteriorate.

The social impact of the pollution has extended to children. The incidence of health problems has been most common amongst children in the local communities, and this is increasing. When they become ill they are unable to attend school or college, affecting their education.

4.2 Economic

Interviews with affected farmers, such as Jagat Singh (see 2.3.2), highlight the impact of pollution on the agricultural industry. This is the main, and often only, source of income and employment in rural areas of India. The more sensitive crops, such as sugarcane and rice, are no longer able to grow in much of the land adjacent to the river, and hardier crops fail to attract the same level of income. Poor-quality sugarcane, a longer distance away, is attracting 50% less revenue than that of healthy sugarcane. Thus the pollution produced by the paper mill has effectively halved the agricultural industry in the vicinity of the paper mill.

There has been a negative impact on local productivity. Illnesses such as jaundice are expensive to cure and take weeks, sometimes months, to recover from. This can represent a sizeable loss of earnings for affected families. Falling ash that is increasingly impairing local people's vision will increasingly affect the ability of people to work, restricting productivity in the local area.

The health of vital animals such as buffalos will affect the quantity of milk that can be produced from a potentially decreasing population (as animals increasingly die from exposure to pollution). Families that rely on income from milk will suffer, as will farmers that rely on cattle to plough their land.

4.2 Environment

The pulp and paper manufacturing plant operated by Shakumbhri Straw Products Limited (SSPL) constantly releases high volumes of effluent into the Aril River. This pollution is flowing through various tributaries to eventually find its way into the River Ganges. Pollution from the paper mill is directly impacting the environment for thousands of kilometres along the river network towards Bangladesh.

The paper mill also constantly emits smoke from its chimneys. The gases emitted contribute to localised air pollution, whilst an intense sulphuric smell permanently engulfs the entire area surrounding the paper mill. The gases emitted contribute to global environmental problems.

Increasing levels of falling ash add to the fine layers of ash already settled on much of the surrounding environment. As soils lose nutrients, the growth of plants is stunted, and animal species will inevitably become locally extinct. As water pollution increases, the environment will eventually become too poisonous for fish and amphibian species to survive in, and bird species will also become locally extinct as a result.

5. Recommendations

The purpose of this report has been to provide concerned stakeholders with authoritative and researched advice on how best to assess and tackle the problems associated with the illegal levels of pollution from Shakumbhri Straw Products Limited (SSPL).

5.1 *Greater range of tests and more frequent*

It is necessary to test the chemical composition of the polluted river water. The chemical pollutants associated with the paper and pulp industry are documented in the Annex. A composition test will precisely pinpoint which pollutants are present, enabling a more accurate assessment to take place regarding the environmental and health implications of the pollution. Composition tests will also determine how mobile the contaminants are through the ground. Chemicals (the pollutants) vary in solubility; the more soluble a contaminant is, the less mobile it will be, and the less risk it poses to the groundwater supply. Further tests on the chemical composition of water coming out of roadside pumps should be done to test for evidence of seepage of polluted river water into groundwater supplies

5.2 *The specific electrical conductivity test*

Experts at a leading environmental consultancy in the field of land contamination have recommended testing the specific electrical conductivity of the Aril River's water. This tests the water's ability to conduct an electric current. Specific conductance is a useful water-quality measurement as it provides an accurate measure of the level of dissolved material in the water.

A high specific conductance indicates high dissolved-solids concentration, and adversely affects the suitability of the water for domestic, industrial and agricultural uses. If the water is used for drinking purposes it can have an unpleasant taste and odour, and can lead to health problems such as gastrointestinal distress. In the context of the Aril water pollution, such a test will help to determine a link between the river pollution and the health problems (particularly diarrhoea) experienced by the nearby communities to the Aril. Thus it would also be useful to conduct the test on the water generated by the roadside pumps in Amarpurkashi.

The test can determine the salinity of the water. This is important in the context of the Aril River and surrounding land, as much of the land is used for agricultural purposes. Crops cannot survive when exposed to water with a high salinity. A simplified version of the specific electrical conductivity test can be carried out using school equipment, to measure the salinity of the water. Our fieldwork in Amarpurkashi revealed that the nearby sugarcane plantations yield crops of a far poorer quality since the introduction of the paper mills to the area, a pattern that has been worsening over time.

5.3 *Shakumbhri's supply chain*

The supply chain of the company provides an ideal opportunity to bring about change without having to directly interact with the company itself. Targeting the supply chain of SSPL through awareness campaigns that increase exposure to Shakumbhri's environmental negligence will, if effectively done, hurt the image and credibility of SSPL. Which companies do they supply? Which companies supply Shakumbhri? Who is funding Shakumbhri's operations? Are these organisations aware of Shakumbhri's environmental negligence?

5.4 *Geology of the area*

According to the Pulp and Paper Industry Profile by the Department of the Environment (1996), the risk to the groundwater supply from contamination depends on the properties of the soil. Natural organic matter helps to absorb contaminants thereby restricting their mobility, as does a high clay content of the soil. Soil consisting of coarse-grained sands and gravels with little natural organic content will enable greater migration of contaminants.

Therefore, to help assess the risk of contamination of the groundwater supply, the ecology of the soil on which the Aril River lies should be analysed.

There is a desperate need for accurate, conclusive evidence that undeniably links the pollution to the vast problems detailed in this report. Only then will more attention, in political, legal and public spheres, be afforded to a problem that urgently needs to be resolved. Polluting illegally is a common problem in India. Water resources used in agriculture, industry, and consumption, have not been treated for safe use. The resulting health problems in areas affected by illegal pollution are no coincidence. If a government body, at any level, needs any incentive at all to address illegal pollution, then this should be the reason.

References

Department of the Environment (1996) *Industry Profile: Pulp and Paper Manufacturing Works*. (Sponsored by Contaminated Land and Liabilities Division). London: Crown Copyright.

Environment Agency (1998) *Water*. Welwyn Garden City: Environment Agency. [Online] Available at: <http://enquire.hertscc.gov.uk/qol/1998/water98.pdf> [Accessed 11 July 2010]

Environment Agency (2004) *Water Framework Directive Programme: Technical Assessment Method*. [Leaflet] Bristol: Environment Agency.

U.S. Geological Survey (2010) *Common Water Measurements*. [Online] (Updated 29 March 2010) Available at: <http://ga.water.usgs.gov/edu/characteristics.html#ph> [Accessed 10 July 2010]

United Utilities (2010) *The pH of Drinking Water*: United Utilities. [Online]. Available at: <http://www.unitedutilities.com/ThepHofdrinkingwater.aspx> [Accessed 21 July 2010]

Annex Potential contaminants

Pollutant Category	Pollutant
Metals and metallic compounds	Aluminium sulphate (size) Phenylmercuric compounds Ethylmercuric compounds (biocides) Chromium salts Iron salts Cadmium salts (dyes)

Inorganic elements and compounds	<p>Hyphochlorites Chlorates Boron compounds Thiosulphates Sulphates Sulphites Suphides Bisulphites Hydrosulphites Sulphur Phosphates Ochre, sienna (dyes)</p>
Acids	Suphuric
Alkalis	Sodium hydroxide
Solvents (for pulp production)	<p>Acetic acid Formic acid Sulphonic acid Sulpholane Glycols Acetone Phenol Cresol Monoethanolamine Triethanolamine Ethanol Methanol</p>
Organic compounds	
Size	E.g. rosin, alkyl ketene dimer (AKD), alkyl succinic anhydride (ASA)
Wet strength additives	E.g. urea formaldehyde resins, aminopolyamide-epichlorohydrin resins
Dry strength additives	E.g. acrylamide polymer, wax emulsions
Coatings	E.g. polyvinyl alcohol, carboxy-methyl cellulose, styrene butadiene latex
Softening agents (for tissues)	E.g. quaternary ammonium salts
Optical brightening agents	E.g. bis(triazinyl-amine)-stilbene disulphonate
Barriers and coatings	E.g. nitriles, acrylics
Dyes	E.g. indigo, alizarin
Chlorinated organic compounds (from the use of chlorine)	E.g. chlorinated phenols, dioxins, furans, fatty alcohol polyalkylene glycols, alkylphenol ethoxylate
Biocides	E.g. dichlorphen, bromonitrostyrene, bromonitropropandiol, bistiocyanate, organobromine compounds, organosulphur compounds, aldehydes

Pesticides	E.g. lindane (in imported pulp)
Oils	Fuel oils Lubricating oils Mineral oils (from ink-related processes)
Polychlorinated biphenyls (PCBs)	

Appendix November 2009 test results

Parameters	Site 1: Palanpur		Site 2: Ramchandra		Site 3: Shakumbhri		Site 4: Devri	
	5/4/2002	26/10/2009	5/4/2002	26/10/2009	5/4/2002	26/10/2009	5/4/2002	26/10/2009
pH	8.5	7.7	9.5	8.8	10	7.8	9.5	7.6
SS	380	123	1500	4145	2900	4134	1780	1006*

DS		503		3135		1616		1939
BOD	192	102*	1070	5.4*	1370	10.5*	1400	8.5*
COD		260		Nil		Nil		Nil
Colour	Blackish-Red	Brown	Dark Brown	Black-Yellow	Dark Brown	Black-Yellow	Dark Brown	Black-Yellow
Odour	Faint-Sweet	Pungent	Very Pungent	Very Pungent	Very Pungent	Very Pungent	Very Pungent	Very Pungent

Key

SS	Total Suspended Solids	mg/l
TDS	Total Dissolved Solids	mg/l
BOD	Biological Oxygen Demand	3 Day's at 27°C, mg/l
COD	Chemical Oxygen Demand	mg/l

*Anomalous data

Additional parameters

Total dissolved solids (TDS)

Total dissolved solids is the sum total of all of the dissolved substance in a given body of water. It could include hardness, alkalinity, cyanuric acid, chlorides, bromides, sulphates, silicates, and organic compounds. Any addition to water will increase its TDS. This includes not only sanitizing and pH adjusting chemicals, but also conditioner, algacides, and tile and surface cleaners. It includes airborne pollutants and dissolved minerals in the fill water. At low levels, TDS does not present a

problem. In fact, a certain amount of TDS is necessary for water balance. Hardness and Total Alkalinity are both part of TDS.

Chemical oxygen demand (COD)

Chemical oxygen demand (COD) is a measure of the capacity of water to consume oxygen during the decomposition of organic matter and the oxidation of inorganic chemicals such as ammonia and nitrite. COD measurements are commonly made on samples of waste waters or of natural waters contaminated by domestic or industrial wastes. Many governments impose strict regulations on the maximum COD of waste water before it can be returned to the environment. For example, in Switzerland regulations stipulate a COD of no more than 1000mg/l.

Full test results, April 2002

Parameters	Site 1: Palanpur	Site 2: Ramchandra	Site 3: Shakumbhri	Site 4: Devri
ph	7.7	8.8	7.8	7.6
TSS	123	4145	4134	1006
TDS	503	3135	1616	1939
BOD	102	5.4	10.5	8.5
COD	260	Nil	Nil	Nil
Colour	Brown	Black-Yellow	Black-Yellow	Black-Yellow
Odour	Pungent	Very Pungent	Very Pungent	Very Pungent

Key

TSS	Total Suspended Solids	mg/l
TDS	Total Dissolved Solids	mg/l
BOD	Biological Oxygen Demand	3 Day's at 27°C, mg/l
COD	Chemical Oxygen Demand	mg/l

Comparison of April 2002 and October 2009 results

The time gap between the two rounds of testing is more than 7 years and 6 months. Accounts given by local people strongly indicate that the pollution has significantly worsened during this period. Yet the results from the October 2009 tests are somewhat ambiguous. According to research, the latest data indicate that in some ways the pollution has actually improved, particularly where BOD is concerned. For example, the site with the worst BOD in 2002 was Devri at 1400mg/l, yet in 2009 this has dropped to just 8.5mg/l. This represents an improvement in classification from *Very Poor*: *Very*

Polluted to Poor: Somewhat Polluted.

The same is also evident with TSS, again for example at Devri where the TSS has fallen from 1780mg/l to 1006mg/l. One explanation for these unexpected results could be related to the timing of each round of testing. The tests in April 2002 were conducted two months *before* the annual monsoon season (June-August), whereas the subsequent tests in October 2009 were conducted two months *after* the annual monsoon (also note that the 2009 monsoon rains arrived more than a month late).

According to accounts given by farmers and village chiefs, the Aril River annually bursts its banks during the monsoon season. This causes the pollution to spread over surrounding fields and thus the river pollution becomes diluted and dissipates. This goes some way to explaining why the test results for October 2009 indicate lower levels of pollution for certain parameters at certain sites along the river.

Biological Oxygen Demand (BOD)

The BOD of waste water along the four sites of the Aril River varies substantially. Whilst at Palanpur the BOD is as high as 102mg/l, at Ramchandra the corresponding figure is just 5.4mg/l. Surprisingly these figures do not fare too poorly according to research on BOD data: the waste water at Ramchandra is only categorised as *moderately polluted*; the waste water at Shakumbhri and Devri is categorised as *efficiently treated sewage* (despite what we know of Shakumbhri's unwillingness to treat its waste effluent); and only at Palanpur (the farthest site upstream) is the BOD categorised as untreated sewage.

Chemical Oxygen Demand (COD)

Despite our best efforts we have been unable to apply any meaning to the data generated for COD. Again there is some discrepancy, ranging from *Nil* to 260mg/l. Only at Palanpur is some COD registered, and at 260mg/l the COD seems to be well within the safe limits as stipulated by strict Western governments such as Switzerland's, which requires waste water to have a COD of less than 1000mg/l. The data generated under this parameter in particular raises serious questions regarding the accuracy of the test results (produced by the DWGTL).