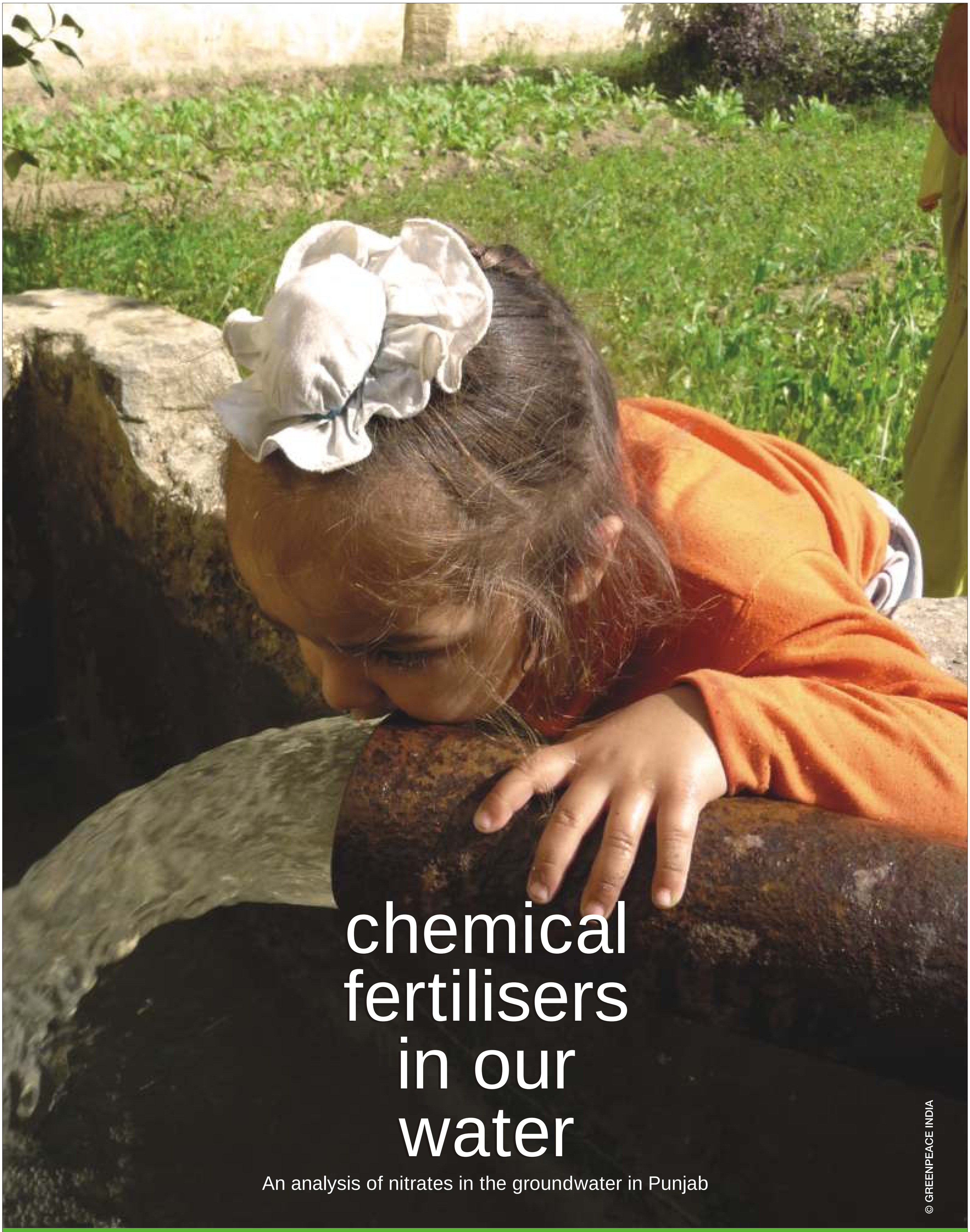

chemical fertilisers in our water

An analysis of nitrates in the groundwater in Punjab

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COVER IMAGE
Child drinks water from the water pump near his house in Faridkot, Punjab. Babies and infants living around agricultural areas who are fed water from wells and pumps are the most vulnerable to health risks from nitrates like blue baby syndrome and cancer.

IMAGE CREDIT
Preethi Herman

Contents

This is Greenpeace

Greenpeace is a global campaigning organisation that acts to change attitudes and behaviour, to protect and conserve the environment and to promote peace by:

Catalysing an energy revolution to address the number one threat facing our planet: climate change.

Defending our oceans by challenging wasteful and destructive fishing, and creating a global network of marine reserves.

Protecting the world's remaining ancient forests and the animal, plants and people that depend on them.

Working for disarmament and peace by reducing dependence on finite resources and calling for the elimination of all nuclear weapons.

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Greenpeace exists because this fragile earth deserves a voice. It needs solutions. It needs change. It needs action. Greenpeace's goal is to ensure the ability of the earth to nurture life in all its diversity. At Greenpeace, we believe in the power of the many. The future of the environment rests with the millions of people around the world who share our beliefs. Together we can tackle environmental problems and promote solutions.

Introduction

A chemical intensive model of agriculture was introduced in India in the 1960s as part of the Green Revolution. This model and the supporting government policies, such as the chemical fertiliser subsidy policy, provoked indiscriminate use of chemicals. This has not only led to deterioration of the environment but also degraded and contaminated the natural resources base, and is now posing a threat to human health.

A recent Greenpeace Research Laboratories investigation on the effects of synthetic nitrogen fertiliser on groundwater pollution in intensive agriculture areas in three districts of Punjab shows that 20 percent of all sampled wells have nitrate levels above the safety limit of 50 mg of nitrate per litre (50mg/L NO_3^- for drinking water established by the World Health Organisation (WHO). This nitrate pollution is clearly linked with the usage of synthetic nitrogen fertilisers as higher the application of nitrogen (urea) in the adjoining field, the higher the nitrate pollution found in the drinking water from the same farm.

Nitrate pollution in drinking water can have serious health impact on humans, especially for babies and children. The most significant potential health effects of drinking water contaminated with nitrate are the blue-baby syndrome (methemoglobinemia) and cancer.

Ironically, this intensive farming practice is also not living up to its promise of sustained increase in food production. As a consequence, food production is now affected by diminishing returns and falling dividends in agriculture intensive areas. Application of nitrogen fertilisers compromises future food production by degrading soil fertility, and compromises the health of the farmers and their families by polluting the drinking water they depend on. The situation is alarming as the intensive model of farming has already depleted the groundwater. This region might be suffering from widespread nitrate pollution on its diminishing sources of drinking water.

There is an urgent need to shift to an eco-friendly agricultural model, and identify agro-ecological practices that ensure future food security. It is necessary now to acknowledge the pattern of the hazards that is becoming a trend, and address them with research, political will, relevant policy and practices.

Image: Fertiliser industry in Bhatinda, Punjab. Greenpeace's recorded data on agronomic practices shows an average application rate of 322 kg N per hectare in 2008-09 in the three districts of Bhatinda, Ludhiana and Muktsar. It is higher than the averages reported by the Fertiliser Association of India for Punjab (210 kg N per hectare for 2006-07)

Image: Algae bloom covers the entire pond making the water look green. The bloom is caused by nitrogen loads in the environment. In urban areas it is associated with sewage and in agriculture areas, with livestock sources and nitrogen fertiliser inputs.

The study - process and findings

This study is an initial Greenpeace Research Laboratories investigation into the effects of synthetic nitrogen fertiliser on groundwater pollution in intensive agriculture areas in Punjab. We tested the level of nitrate in drinking water from groundwater artesian wells located within farms and surrounded by crops (mostly rice and wheat rotations).

Nitrate pollution in groundwater is associated with nitrogen loads in the environment. In urban areas, it is associated with sewage and in agriculture areas, with livestock sources and nitrogen fertiliser inputs.

Image: A farmer washes radish from his farm in the water pumped from the well. A Greenpeace investigation shows that 22 percent of all sampled wells have nitrate levels above the safety limit of 50mg/L NO_3^- for drinking water established by the World Health Organisation (WHO).

Sampling and testing methodology

- We tested groundwater from artesian wells located in farms away from other potential sources of nitrate contamination (animals, human sewage), in order to focus on the impact of fertiliser application. We sampled farms located in three districts in Punjab where fertiliser consumption is highest. Districts:
  - Ludhiana, 18 farms sampled, average well depth 160 feet.
  - Muktsar, 18 farms sampled, average well depth 51 feet.
  - Bhatinda, 14 farms sampled, average well depth 157 feet.

- Fifty groundwater wells were sampled in farms (with samples duplicated for higher accuracy) and 50 farmers were interviewed for data recording on agronomic practices. When sampling groundwater, we let the water outlet (i.e., a hand or electric pump) run for approximately three minutes before collecting the sample in a sterile plastic bottle. Measurements of pH and electric conductivity (EC) were taken on site at the time of sampling (Hanna Instruments, UK).

- Nitrate concentration (mg/L NO_3^-) in water samples was tested colorimetrically with the chromotropic acid method (Method 10020, Test 'N Tube™ Vials, Hach Lange, UK), using a portable spectrophotometer (DR2400, Hach Lange, UK). The value given for each sample is the average of testing two or three sub-samples for improved accuracy. Samples were kept in a cool box after collection and were tested with a portable Hatch Spectrophotometer within ten hours maximum on the same day.

- All the water tested is used for drinking by farmers and families and farm workers.

- As control points, we sampled two wells that are also monitored by the Central Groundwater Control Board (CGWB). These wells are located within the villages, with high pollution probably coming from concentration of human sewage and cattle. The comparable values from our tests and from the reported values by CGWB point to the agreement between our methodologies.

Table 1. Results of control tests in two wells monitored by the Central Groundwater Control Board and sampled by our team in 2009. (CGWB values provided by the office of the Director of CGWB in Chandigarh, March 2009)

District, Block, Village	CGWB well ID	Well location	Nitrate (mg/L NO_3^-)	*Reported CGWB Nitrate value in same well*
Muktsar, Muktsar, Muktsar	CGWB 44J-3C1	In village	110.7	*175*
Muktsar, Gidderbaha, Doda	CGWB 44J-3C8	In village	601.6	*578*

Findings

Drinking water extracted from artesian wells in agricultural areas Punjab shows high pollution with nitrates, and this pollution correlates with intensive farming practices where nitrogen fertilisers are applied in excess (Figures 1 and 2).

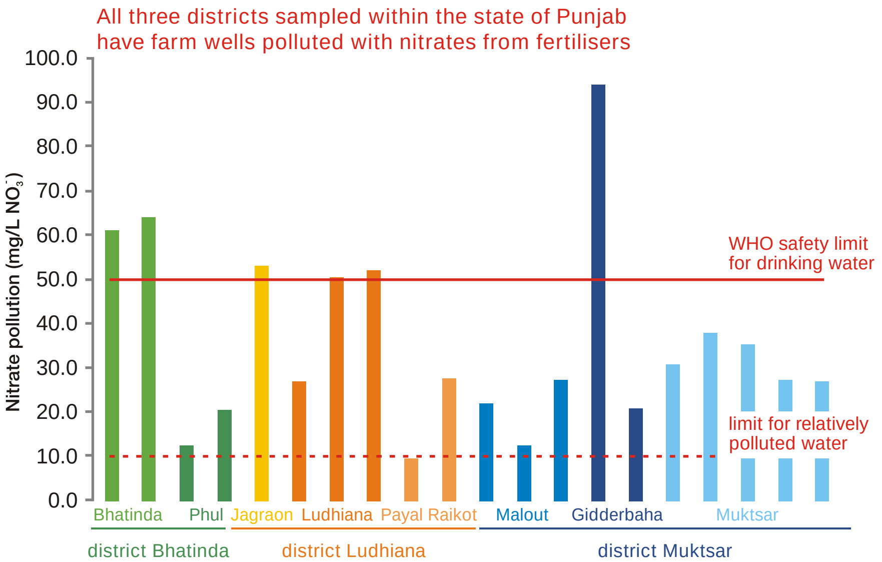
Ten of 50 sampled wells, i.e., 20 percent of all sampled wells, have nitrate levels above the safety limit of 50 mg/L NO_3^- for drinking water established by the World Health Organisation (WHO) (see Table A1 in Appendix and Figure 1).

The three sampled districts show groundwater wells that are highly polluted with nitrates, and 44 percent of the farming villages sampled (8 of 18 villages), have wells with pollution higher than the safety limit for drinking water.

higher than the averages reported by the Fertiliser Association of India for Punjab (210 kg N per hectare for 2006-07), while the data we recorded from 50 farmer interviews show an average application rate of 322 kg N per hectare in 2008-09. The nutrient demand of the crops is only about 100 Kg N per hectare, and scientific studies show that the best option is to add this nitrogen through organic fertilisers (legumes, manure, etc.) to ensure soil fertility (Mader *et al.*, 2002).

The nitrate pollution found in this study is remarkably high given that the groundwater in this area is quite deep, and it is generally assumed that deep groundwater would be cleaner and less polluted than shallow water. This represents a worrisome fact, given the serious status of groundwater depletion in this region. In addition to depleted

Figure 1. Nitrate concentration in each blocks (or tehsils) in Punjab where 50 groundwater wells were sampled in rice and wheat farms. We sampled farms located in three districts, Bhatinda, Ludhiana and Muktsar, covering nine blocks and 18 villages.



groundwater linked to intensive agriculture, the region might be suffering from widespread nitrate pollution in its diminishing sources of drinking water.

This nitrate pollution is clearly linked with excess use of synthetic nitrogen fertilisers (Figure 2). Figure 2 shows the correlation between application of nitrogen in the farm (mostly urea) and the nitrate pollution found in the groundwater well on the same farm: the higher the application of nitrogen (urea), the higher the nitrate pollution found in the drinking water from the same farm.

The data we recorded on agronomic practices show that nitrogen application is

Excess application of nitrogen fertilisers not only compromises future food production by degrading soil fertility (as recently highlighted in our report Subsidising Food Crisis (Roy *et al.*, 2009)), but also compromises the health of the farmers and their families by polluting the drinking water they depend on.

Figure 2. Relationship between nitrogen application rate in a farm and nitrogen concentration in the groundwater well in the same farm. This analysis include the data points that fall within the median range of well depth (50-150 m), to exclude extreme samples in both ends.

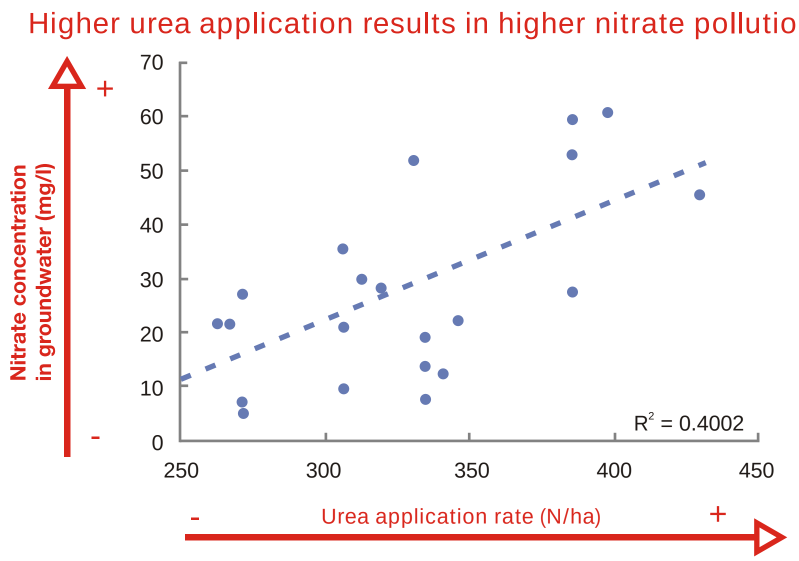


Image: A farmer carrying a sack of chemical fertiliser to the field in Bhatinda, Punjab. Application of nitrogen fertilisers compromises future food production by degrading soil fertility; and compromises the health of the farmers and their families by polluting the drinking water they depend on.

Potential health impact of drinking water contaminated with nitrates

Nitrate pollution in drinking water in agriculture areas come mainly from nitrogen fertilisers applied to farm soils (Galloway *et al.*, 2003).

A large part of the nitrogen applied to soils is not taken up by the plant and ends up in the soil (Vitousek *et al.*, 2009), from where it moves to the atmosphere and to water bodies (groundwater, lakes, river, and coastal areas) where it contaminates drinking water and the environment (Galloway *et al.*, 2003).

The most significant potential health effects of drinking water contaminated with nitrate are blue-baby syndrome (methemoglobinemia) and cancer.

Babies and infants living around agricultural areas and who are fed water from wells are the most vulnerable to health risks from nitrates. Additionally, anyone drinking from a contaminated well or eating vegetables with high levels of nitrate could be vulnerable to the long term effects of nitrates, like various types of cancer (Ward *et al.*, 2005).

Blue-baby syndrome

The greatest risk of nitrate poisoning (methemoglobinemia) occurs in infants fed with well water contaminated with nitrates, and affects particularly babies who are four months old or younger (Greer *et al.*, 2005).

Blue-baby syndrome (or methemoglobin-emia) occurs when the haemoglobin in the blood loses its capacity to carry oxygen, and this can ultimately cause asphyxia and death. This occurs because nitrites (resulting from the reduction of the nitrate in the anaerobic conditions of the digestive tract) block haemoglobin in the blood (Greer *et al.*, 2005).

Blue-baby syndrome can provoke cyanosis, headache, stupor, fatigue, tachycardia, coma, convulsions, asphyxia and ultimately death (Camargo and Alonso, 2006, Greer *et al.*, 2005).

Since 1945, more than 3,000 cases of blue-baby syndrome have been reported worldwide, most of which were associated with private wells in farming areas with high nitrate concentrations (concentrations > 50 mg/l NO_3^-). Some health professionals believe that the blue-baby syndrome is often under- or misdiagnosed (Townsend *et al.*, 2003).

Cancer

Drinking water contaminated with nitrates or eating food similarly affected has a potential role in developing cancers of the digestive tract, and has also been associated with other types of cancer (non-Hodgkin's lymphoma and bladder and ovarian cancers) (Townsend *et al.*, 2003, Ward *et al.*, 2005).

The link between nitrates and cancer comes from the contribution of nitrates to the bacterial formation of N-nitroso compounds (like nitrosamines) in the digestive tract, particularly in the stomach. These nitrosamines are among the most potent of the known carcinogens in mammals (Camargo and Alonso, 2006, Ward *et al.*, 2005).

Some studies have shown that long-term consumption of drinking water with nitrate concentrations even below the maximum safety level of 50 mg/l NO_3^- may stimulate the formation of these nitrate-related carcinogens (nitrosamines) in the digestive system (Ward *et al.*, 2005).

For example, in Iowa (USA), the levels of nitrate in drinking water below the recommended WHO concentration standard have been linked with an increased risk of bladder and ovarian cancers in women drinking water from municipal and private farm wells (Weyer *et al.*, 2001).

A recent study in Taiwan showed that drinking water with high levels of nitrates was associated with increased risk of cancer of the bladder (Chiu and Tsai, 2007).

Image: This train that travels through Bhatinda to Bikaner, Rajastan is also known as the cancer train. It routinely carries cancer patients from Bhatinda who travel to Bikaner for treatment at the government's regional cancer center.

Acknowledgements:
We would like to thank the 50 farmers who allowed us to carry out the investigation tests in their fields and in the process taught us a lot about farming in the Malwa region of Punjab.

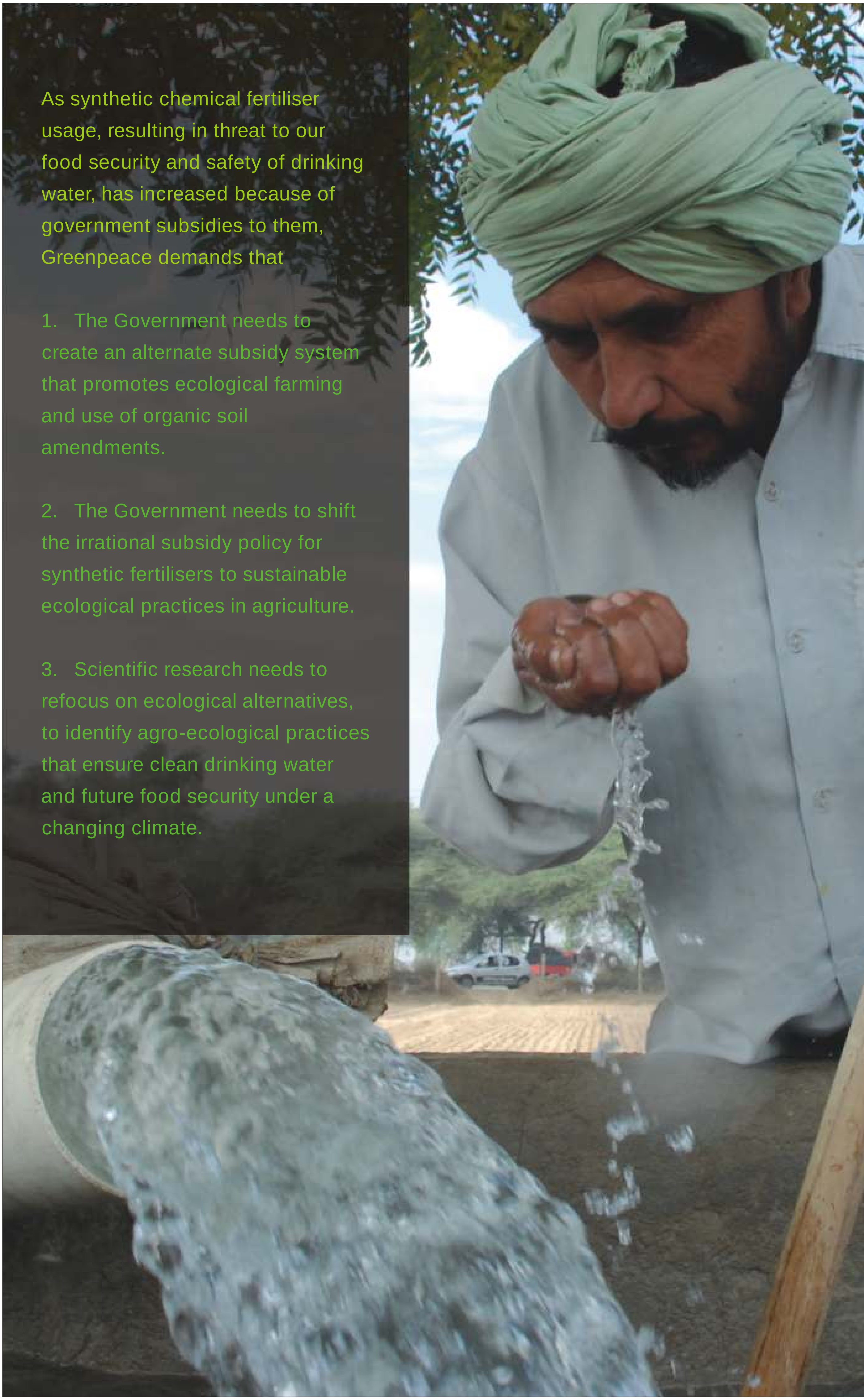
Image: A child washes her hands in the canal that provides ground water to the radish fields in Punjab. Babies and infants living around agricultural areas who are fed water from wells and pumps are the most vulnerable to health risks from nitrates.

As synthetic chemical fertiliser usage, resulting in threat to our food security and safety of drinking water, has increased because of government subsidies to them, Greenpeace demands that

1. The Government needs to create an alternate subsidy system that promotes ecological farming and use of organic soil amendments.

2. The Government needs to shift the irrational subsidy policy for synthetic fertilisers to sustainable ecological practices in agriculture.

3. Scientific research needs to refocus on ecological alternatives, to identify agro-ecological practices that ensure clean drinking water and future food security under a changing climate.



APPENDIX

Table A1. Results for every farm and water well sampled in Punjab in 2009. In red are values that are above the WHO safety limit for drinking water of 50 mg/L.

District	Block or Tehsil	Village	Sample ID	pH	EC mS	Depth of well (m)	Nitrogen application (N/ha)	Nitrate (mg/ L NO_3^-)
Bhatinda	Bhatinda	Pathrala	BH12	7.3	3.6	80	276	64.3
Bhatinda	Bhatinda	Pathrala	BH13	7.1	6.3	85	430	45.6
Bhatinda	Bhatinda	Pathrala	BH14	7.2	3.6	40	272	55.1
Bhatinda	Bhatinda	Raikekalam	BH5	7.2	2.2	110	272	27.0
Bhatinda	Bhatinda	Raikekalam	BH6	7.4	2.2	140	385	53.2
Bhatinda	Bhatinda	Raikekalam	BH7	7.4	2.4	100	398	61.0
Bhatinda	Bhatinda	Raikekalam	BH8	7.5	0.7	50	272	5.0
Bhatinda	Bhatinda	Raikekalam	BH9	7.1	1.7	90	272	6.9
Bhatinda	Bhatinda	Raikekalam	BH10	7.3	1.2	105	385	59.6
Bhatinda	Bhatinda	Raikekalam	BH11	7.9	1.7	45	340	25.9
Bhatinda	Phul	Bhairupa	BH1	7.3	1.5	300	272	20.5
Bhatinda	Phul	Bhairupa	BH2	7.7	1.3	450	302	0.5
Bhatinda	Phul	Dialpura	BH3	7.6	1.2	350	306	12.5
Bhatinda	Phul	Dialpura	BH4	7.1	1.8	250	272	7.6
Ludhiana	Jagraon	Manuke	LU1	7.3	1.0	300	315	15.2
Ludhiana	Jagraon	Manuke	LU2	7.4	1.1	80	335	19.1
Ludhiana	Jagraon	Manuke	LU3	7.5	1.3	90	385	53.0
Ludhiana	Ludhiana	Bhairo Munna	LU6	7.3	1.0	100	263	21.5
Ludhiana	Ludhiana	Bhairo Munna	LU7	7.4	0.9	150	320	28.1
Ludhiana	Ludhiana	Bhairo Munna	LU8	7.2	0.8	150	335	7.6
Ludhiana	Ludhiana	Bhairo Munna	LU9	7.3	1.0	100	335	13.7
Ludhiana	Ludhiana	Bhairo Munna	LU11	7.0	0.8	100	331	52.0
Ludhiana	Ludhiana	Bhutahari	LU12	7.9	0.3	305	372	0.7
Ludhiana	Ludhiana	Bhutahari	LU13	7.0	0.7	100	341	12.3
Ludhiana	Ludhiana	Bhutahari	LU14	7.6	0.3	270	306	3.2
Ludhiana	Ludhiana	Bhutahari	LU15	7.3	0.5	180	306	15.4
Ludhiana	Ludhiana	Bhutahari	LU18	6.9	0.7	160	284	50.6
Ludhiana	Ludhiana	Bhutta	LU19	7.1	1.0	65	306	21.0
Ludhiana	Ludhiana	Bhutta	LU20	6.9	1.1	70	249	27.0
Ludhiana	Payal	Siahar	LU16	7.3	0.7	200	311	7.8
Ludhiana	Payal	Siahar	LU17	6.9	0.7	115	306	9.5
Ludhiana	Raikot	Jhoorda	LU4	7.2	1.2	350	442	27.9
Muktsar	Gidderbaha	Bhalaina	MU8	7.6	2.0	50	306	20.9
Muktsar	Gidderbaha	Doda	MU4	6.9	3.3	80	272	72.8
Muktsar	Gidderbaha	Doda	MU5	7.5	3.2	50	335	94.3
Muktsar	Malout	Abul Khurana	MU9	7.1	1.4	60	385	27.6
Muktsar	Malout	Abul Khurana	MU10	7.5	1.4	40		9.8
Muktsar	Malout	Kutianwali/Sherawali	MU14	7.4	2.4	40	261	12.8
Muktsar	Malout	Lambi	MU11	6.9	1.6	80	346	22.2
Muktsar	Malout	Lambi	MU12	7.7	2.3	25		23.2
Muktsar	Muktsar	Muktsar	MU2	7.3	1.3	90	431	7.4
Muktsar	Muktsar	Muktsar	MU3	7.5	1.8	20	374	27.1
Muktsar	Muktsar	Sakhanwali	MU21	6.9	3.8	45	278	27.5
Muktsar	Muktsar	Sangrana	MU22	7.3	2.6	35	278	40.8
Muktsar	Muktsar	Seerwali	MU15	7.2	1.8	50	335	29.1
Muktsar	Muktsar	Seerwali	MU16	7.0	1.5	25	324	38.0
Muktsar	Muktsar	Seerwali	MU17	7.0	4.2	50	267	21.6
Muktsar	Muktsar	Vangal	MU18	7.1	6.5	50	312	29.9
Muktsar	Muktsar	Vangal	MU19	7.2	5.2	50	306	35.5
Muktsar	Muktsar	Vangal	MU20	7.4	1.6	70	335	29.8

REFERENCES

Camargo, J. A. and Alonso, A. 2006. Ecological and toxicological effects of inorganic nitrogen pollution in aquatic ecosystems: A global assessment. Environment International 32: 831.

Chiu, H. F. and Tsai, S. S. 2007. Nitrate in Drinking Water and Risk of Death from Bladder Cancer: An Ecological Case-Control Study in Taiwan. Journal of Toxicology and Environmental Health, Part A 70: 1000-1004.

Galloway, J. N., Aber, J. D., Erisman, J. W., Seitzinger, S. P., Howarth, R. W., Cowling, E. B. and Cosby, B. J. 2003. The Nitrogen Cascade. BioScience 53: 341-356.

Greer, F. R., Shannon, M., Committee on Nutrition and Committee on Environmental Health 2005. Infant methemoglobinemia: the role of dietary nitrate in food and water. Pediatrics 116: 784-786.

Mäder, P., Fließbach, A., Dubois, D., Gunst, L., Fried, P. and Niggli, U. 2002. Soil Fertility and Biodiversity in Organic Farming. Science 296: 1694-1697.

Roy, B. C., Chattopadhyay, G. N. and Tirado, R. 2009. Subsidising Food Crisis: Synthetic Fertilisers Lead To Poor Soil and Less Food. Greenpeace India. http://www.greenpeace.org/india/press/reports/subsidising-food-crisis.

Townsend, A. R., Howarth, R. W., Bazzaz, F. A., Booth, M. S., Cleveland, C. C., Collinge, S. K., Dobson, A. P., Epstein, P. R., Holland, E. A. and Keeney, D. R. 2003. Human health effects of a changing global nitrogen cycle. Frontiers in Ecology and the Environment 1: 240-246.

Vitousek, P. M., Naylor, R., Crews, T., David, M. B., Drinkwater, L. E., Holland, E., Johnes, P. J., Katzenberger, J., Martinelli, L. A. and Matson, P. A. 2009. Nutrient imbalances in agricultural development. Science 324: 1519.

Ward, M. H., deKok, T. M. and Levallois, P. 2005. Workgroup report: drinking-water nitrate and health-recent findings and research needs. Environmental Health Perspectives 113: 1607-1614.

Weyer, P. J., Cerhan, J. R., Kross, B. C., Hallberg, G. R., Kantamneni, J., Breuer, G., Jones, M. P., Zheng, W. and Lynch, C. F. 2001. Municipal Drinking Water Nitrate Level and Cancer Risk in Older Women: The Iowa Women's Health Study. Epidemiology 12: 327-338.

Image: Intensive model of farming has already depleted the groundwater and this region in Punjab might be suffering from widespread nitrate pollution on its diminishing sources of drinking water. There is an urgent need to shift to an eco-friendly agricultural model, and identify agro-ecological practices that ensure future food security.

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Greenpeace is a global organisation that uses non-violent direct action to tackle the most crucial threats to our planet's biodiversity and environment. Greenpeace is a non-profit organisation, present in 40 countries across Europe, The Americas, Asia and the Pacific.
It speaks for 2.8 million supporters worldwide, and inspires many millions more to take action every day. To maintain its independence, Greenpeace does not accept donations from governments or corporations but relies on contributions from individual supporters and foundation grants.

Greenpeace has been campaigning against environmental degradation since 1971 when a small boat of volunteers and journalists sailed into Amchitka, an area north of Alaska, where the USGovernment was conducting underground nuclear tests.This tradition of 'bearing witness' in a non-violent manner continues today, and ships are an important part of all its campaign work.

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