Punjab's food and water woes: perils of heavy metal contamination

Sarah Iqbal

Punjab's early success in agriculture set the stage for infrastructure development in the region. Within years of embracing seed-fertilizer technology in 1968, the benefits of improved crop production started trickling to other economic sectors[1]. But due to short sighted development and unplanned industrialization, the region has become swamped with toxic heavy metals that are released into the rivers. The problem has been known for some time, but despite that, no concrete solution has been worked out. This does not bode well for health and agriculture. Several reports from the region highlight these issues.

The most recent example in a continuing series is a study by scientists from the Guru Nanak Dev University, Punjab which highlights the problem of heavy metal contamination in soil. High levels of cadmium and cobalt were found in soil sampled from Ropar[2]. The scientists also found that crops grown in such soil carried large amounts of lead (14.11–21.30 mg/kg) and cobalt (12.40–16.80 mg/kg) above the safe limit of 2.5 and 0.48 mg/kg respectively.

'Some heavy metals like copper and zinc are required by the body in trace amounts; but, research shows that excess exposure to heavy metals causes many health problems ranging from bone deformation and neurotoxicity to reproductive defects and cancer', explains Inderpreet Kaur, faculty at the Guru Nanak Dev University and an author on this study.

When Kaur's team tested the heavy metal levels in the edible part of crops, they found that the rice grains were laden with chromium (more than 20 mg/kg) and maize had amassed copious amounts of copper (in excess of 30 mg/kg).

Some areas in Punjab are naturally endowed with heavy metals. A paper published by scientists from Punjab Agricultural University in 2009 shows that discharge from factories and industries could also add to the problem of heavy metal contamination[3]. Researchers sampled soil and crops from three cities differing in terms of industrial activity – Ludhiana, Jalandhar and Malerkotla. Specimens were collected from ten sites irrigated with sewage water and ten sites irrigated through tubewell. The soil and crops were then tested for the presence of cobalt.

The scientists found that, on an average, sewage irrigated soil from the highly industrialized city of Ludhiana had almost two-folds higher cobalt concentration than soil samples from Malerkotla, which is a considerably less industrialized town. A similar pattern was displayed by crops irrigated with sewage water. Mustard, cabbage and cauliflower from Ludhiana had highest cobalt levels, while their counterparts from Malerkotla contained the lowest. In contrast, plants irrigated with water from tube wells did not show any signs of heavy metal accumulation across all cities.

Cobalt can be introduced in the environment by coal burning power plants and alloy industries and has widely varying effects on health. Through this study, scientists make it evident that sewage from industries is rich in heavy metals and its use for irrigation can pollute soil and make crops unfit for consumption. Heavy metals could also lower the fertility of soil over time.

A recent paper, also from the Guru Nanak Dev University, adds weight to these findings[4]. Scientists from the Department of Botanical and Environmental Sciences tested the heavy metal levels in 12 vegetables sourced from three sites across Amritsar city which were exposed to wastewater (but not necessarily used for irrigation). They found that even exposure to wastewater by proximity was sufficient to raise the toxic metal content of crops grown in the area. Green leafy vegetables like spinach, mint and coriander amassed higher levels of the metals as opposed to garlic and onion. The level of uptake was also greater for iron followed by cobalt and least for lead.

Bulk of this problem arises because of wastewater released into rivers, especially from highly industrialized towns. This has been highlighted in a report published by the Punjab pollution control board in 2016. Water samples tested from 37 sites across the course of Sutlej, document the categorical deterioration of water quality as it enters the state through Ropar. By the time the river had passed through industrialized Ludhiana, the water quality degraded to category D leaving it unfit for fishing, bathing and irrigation[5]. Apart from industrial and sewage wastes, there is excessive use of fertilizers and pesticides in the region. A report by Greenpeace states that farmers add 3 times the required amount of fertilizer and pesticides to the soil[6].

A huge fraction of chemicals released into the river can percolate into the soil, and over time, contaminate the groundwater. In a study published in 2017, groundwater from all eight districts in the Malwa region, were found to be strongly affected by heavy metal contamination[7]. Malwa makes up about 44% of Punjab's total area. Scientists sampling the water from this region checked 240 groundwater samples most commonly used for obtaining drinking water.

Researchers found that different heavy metals dominated in different regions. High arsenic levels were found in Ferozpur, extremely high iron concentration (7.6 mg/l) was detected in some samples from Moga and all samples from Muktsar had abundant chromium (3.6 mg/l as opposed to a safe limit of less than 0.5 mg/l) and hence unfit for consumption. Mercury levels were also elevated in all the districts.

Rajni Sharma and Ashit Dutta, researchers from the Bhagwant University, Ajmer carried out this study. They state in their paper that the natural geology of the region plays a part in groundwater contamination. But the way groundwater resources are managed could add to the problem. Overuse and exploitation of groundwater sources can intensify heavy metal contamination. So, does the release of household waste, sewage and industrial effluents into rivers.

This is a matter of concern as unlike other pollutants, heavy metals cannot be broken down into harmless forms by the human body. Rather, they accumulate within the tissues. Here, they interact with sulphur-bound proteins and affect their activity. Kaur and team from the Guru Nanak Dev University found that cobalt was associated with most non-cancer health effects in people from

Ropar. On the other hand, consuming chromium-rich food escalated cancer risk. In tandem with this relationship, many cancer cases of the larynx, breast, etc., have been reported from Ropar. Similar complaints have also been received from Malwa and other areas where soil and water are polluted with heavy metals. There has been a rise in disability among children, cerebral palsy and cases of infertility[6].

In addition to the health of the population, the health of crops also faces major risks. A report published by the planning commission, Government of India in 2013 highlights the dual water crisis in Punjab that has surfaced due to unplanned irrigation practices[8]. The report states that, 'while groundwater is declining at an alarming rate in fresh-water regions, the south-western parts of Punjab are facing problems of severe waterlogging and salinization'. It also states that 'the contamination of drinking water in the water-logged area with uranium, arsenic and heavy metals, etc. is posing a grave threat to the region' and that 'the situation is further aggravated by the fact that there are early indications that the saline water of south-west Punjab may begin to flow into the depleted sweet water aquifers of central Punjab'.

In the wake of these findings, scientists believe that there is a need to create awareness around heavy metal contamination in the region. One area that the state needs to improve in is water use and waste disposal. In this context, the zero liquid disposal policy can come in handy. To manage its water resources, many industries have adopted a zero liquid disposal strategy in which the liquid discharge is recycled for industrial use. This reduces the pressure on water resources in more than one way. But these systems have to be adapted for different industries and there is always scope for improvement, especially with respect to water treatment.

Specialized membranes can be used to filter heavy metal particles from wastewater. On a larger scale, reverse osmosis, a technique that also uses membranes, could be deployed to separate contaminants. But this method is cost intensive and consumes large quantities of power.

A relatively inexpensive method for removing heavy metals from water is through chemical precipitation. Most heavy metal hydroxides and sulphides are insoluble in water. So, by treating the waste with caustic soda or lime, a considerable amount of heavy metals can be eliminated as precipitate. The biggest drawback of this method is that it generates excessive sludge and its disposal can become another problem. A simple alternative to these is the use of adsorbents like activated charcoal[9].

Now, researchers have zeroed in on many low-cost cellulose-based adsorbents like rice husk, sugarcane bagasse, and others derived from agricultural wastes that are inexpensive and can be used for treating heavy metal contaminated effluents[9]. Adsorption-based treatment alternatives are sustainable and could also be downscaled to produce solutions that can be employed by rural households for purifying water.

However, all these solutions represent temporary fixes. While these should be introduced urgently, to combat the menace of heavy metal contamination, the government needs to come up with a long-term strategy for managing both land and water resources. Soil infused with heavy metals can be remediated by growing non-agricultural crops like *Jatropha* and Jerusalem artichoke that can be later used for the production of biodiesel. These plants can hyperaccumulate heavy metals without succumbing to toxicity and serve as a lucrative option for bioremediation, as do microbes.

Now in a process called nano bioremediation, scientists are using bacteria, fungi and plants to generate nanoparticles that are capable of adsorbing heavy metals[10]. Till date, nanoparticles of different materials, shapes and sizes have been produced, all of which adsorb different metals and by different degrees. Some like flower-shaped titanate nanoparticles have a greater adsorption capacity for heavy metals while others, like iron oxide nanoparticles, can act as scaffolds for degrading drugs, pesticides and fertilizers. Presently scientists are testing a range of nanoparticles produced by microbes for their remediation potential. Because this process is environment friendly, energy efficient and requires less time, it could be optimized for wide scale use.

A multipronged approach involving a combination of these strategies may provide the much-needed respite from heavy metal contamination in Punjab.

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Sarah Iqbal
e-mail: sarah.iqbalv@gmail.com