What should be the Coliform standard in India's sewage treatment protocol in order to promote safe reuse of reclaimed water for domestic, industrial and agricultural use; are stringent standards affordable?

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Introduction

The discharge of untreated sewage and the ensuing bacterial contamination of surface water bodies pose a health risk in its reuse, be it for a variety of domestic purposes including safe drinking water, as well as exposing farmers who often use raw sewage or polluted streams to meet their irrigation needs. Not a single city in India has been able, in entirety, to deal with its sewage problem. The gap between sewage generated and the capacity to treat is on the rise, as urban planning and infrastructure is in a shambles.

Politicians continue to fight elections on the promise of providing infrastructure to provide electricity, improve urban mobility and supply safe drinking water. But not a single electorate demands that their ensuing sewage be treated (thumb rule: 80 per cent of water that enters a household leaves as sewage). Therefore often even mere promises are not made to collectively treat a city's sewage, forget drawing up plans on how maximise reuse to curb freshwater demand in attempts to achieve water security. Many cities, downstream of major sewage outfalls have little choice but to use contaminated raw water, treat it as one would sewage, and finally issue a heavy dose of chemical disinfectants that have its own associated health risks.

Towns and cities mindlessly flush their sewage (partially or entirely untreated) over distances without giving much thought to the potential reuse of treated water for a variety of purposes in the urban landscape. Often in the peripheries of cities, or even further out in the rural landscape, this discharge is in fact treated as a resource, but one which carries a health burden. Many thousands of farmers in India use sewage as their primary source of irrigation, thereby putting their health and that of the consumer at risk. Urban India generates more than 40,000 million litres of sewage each day (MLD). And while much of this contributes to the pollution load of water bodies, an estimated 20,000 MLD is currently used for irrigation every day—more than half of it untreated (R C Trivedi, personal communications).

The strength of faecal matter in sewage is monitored by coliform counts, a water quality parameter that acts as an indicator of pathogens that most commonly cause diarrhoea, as well as typhoid and a whole host of enteric diseases. Raw sewage typically has a faecal coliform count in the range of 10^6 up to 10^8 Most Probable Number (MPN)/100ml. While coliform is not a causes of illness, they indicate that pathogenic organisms of faecal origin, be it bacteria, viruses, or protozoa may exist. The Central Pollution Control Board (CPCB) stipulated that the total coliform standard at the intake point for a water treatment plant in India be set at 5,000 MPN/100ml. This is reasonable since clean water technologies and disinfection techniques at conventional water treatment plants can easily deal with this range. But for most Indian towns and cities, inlet parameters far exceed stipulated limits, due to untreated sewage outfalls upstream. The Ministry of Environment and Forests having set limits for several pollution parameters is yet to decide on coliform, a key indicator of pathogenic contamination. The criteria are being developed to be monitored at the outlet of sewage treatment plants. The current norm for total coliform counts under consideration is 10,000MPN/100ml.

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International standard and experiences

Agriculture has to compete for water resources with industry and municipal users, and often there is no alternative for farmers but to use sewage from urban areas directly to water their crops, the scarcity imperative. To ensure safety in its use, voluntary standards were established more than two decades back. In 1989, the World Health Organization (WHO) issued guidelines setting faecal coliform limit at 1,000 MPN/ 100ml to be used for irrigation of crops likely to be eaten uncooked. While the WHO standards were based on a verylow risk, the United States Environment Protection Agency's (USEPA) standards were set on a zero risk philosophy for reuse in urban areas, or for the artificial recharge of aquifers (*see table below*). Stringent limits of faecal coliform in water intended for agricultural use were set at 200 MPN/100 ml.

Type of reuse	Reclaimed quality
Urban reuse	pH 6-9, BOD <10 mg/l, Turbidity < 2 NTU; **No faecal coliform/100 ml**; 1 mg/l residual chlorine.
Agricultural reuse	pH 6-9, BOD < 30 mg/l, SS <30 mg/l; **Faecal coliform <200/100 ml**; residual chlorine.
Ground water recharge	pH 6.5-8.5, Turbidity <2 NTU; **No faecal coliform/100ml**; 1 mg/l residual chlorine; other parameters as potable standards.
Recreational use	<200 TC/100ml

Source: USEPA Guidelines

The approach in the entire United Kingdom has been a little different. The Royal Commission on Sewage Disposal set up in London following the stench and fish kills on account of untreated sewage discharge in the Thames, commenced work in 1898, and over the course of 17 years completed nine voluminous reports. As a result of the Commission's research, standards were notified for effluent discharges, including stringent standards for organic matter (BOD, for instance), suspended solids, nitrogen and phosphorous. No standards were set for coliform on the outlet of a treatment facility, because there is little risk of contamination. Today, a small dose of chemical disinfectants is used for conventional water treatment as gross pollution is absent on account of available freshwater dilution and existing sewage treatment facilities. The populations at risk are mainly swimmers and rowers, where coliform standards have been factored in to the bathing water directive of the European Union (EU).

The EU set the desirable and mandatory limits of faecal and total coliform as a river water quality parameter.All member states, to which the Water Framework Directiveapplies(which set the objectives for water protection in 2000), were given ten years to conform to the values of various parameters laid down in the directive, which is now enforceable. Defining the quality of bathing water, last amended by the Regulation (EC) No.1137/2008 of the European Parliament, parameters were issued with desirable values, along with mandatory values that member countries must meet. The total coliform the guide was set at 500 MPN/100 ml with a mandatory limit of 10,000 MPN/100 ml. For faecal coliform, the guide was set as 100 MPN/100 ml with a mandatory limit set at 2,000 MPN/100 ml. The existing values, it is stipulated, must be met in at least 90 per cent of the samples, with the exception of coliform parameters where the compliance percentage may be 80 per cent. These values "are in the process of being revised and new ones will be operational from 2015," (David Johnstone, personal communications).

Coliform standards in India

In India, given that gross pollution exists due to untreated sewage outfalls, the CPCB has highlighted high coliform levels in lakes and rivers as an area of concern despite expenditure via the various river and lake conservation plans of the Centre. Given that sewage generation outstrips sewage treatment, and use of partially treated sewage for agriculture remainsunregulated, the environment ministry constituted a committee in 1999 which recommended desirable limit of faecal coliform at 1,000 MPN/100mland a maximum permissible limit at 10,000 MPN/100ml for discharge of treated sewage into a water body or reuse for agriculture, aquaculture or forestry applications.While the WHO standard was set based on point of use, the Indian standard is being developed at the outlet of the sewage treatment plant.The Ministry of Urban Development too formed a committee in 2004 that recommended desirable limit of faecal coliform at 500 MPN/100ml and maximum permissible limit at 2,500 MPN/100ml for discharge into the Yamuna stretch in Delhi. The standards were not practicable, given that existing treatment plants were not capable of reducing the coliform count to these levels. The Central Pollution Control Board initiated a study looking at the prevailing sewage treatment technologies and their ability to reduce coliform levels from the inlet to the outlet. Published in 2008, the study sought to evolve techno-economically feasible microbiological standards for disposal of treated sewage.

Source: Columbia Water Center

Use of partially treated water for farming in river floodplains is a common practice in India

Evolving a standard is tricky given the variables at play here. The risk is lowest for crops not meant for human consumption, such as cotton, and others that are processed by heat or drying before consumption (grains, oilseeds, sugar beet). The risk increases in the case of crops normally eaten after cooking (potatoes, eggplant, and beans). The highest risk is for crops that are eaten uncooked and grown in close contact with wastewater effluent (fresh vegetables such as lettuce or carrots, or spray-irrigated fruit), and this is beginning to have a significant health impact. Given the changing nature of sources of infection, it has been ascertained that less than 1-2% of Indian patients with cysticercosis, a disease spread through the faecal-oral route, admit to eating pork. More than 95% patients with cysticercosis have been found to follow a strict vegetarian diet, and this has been found to be more prevalent in northern states of India than the southern states. Consumption of raw vegetables and salads is more prevalent in the North,and is one of the major identified sources of infection (Nandini Sharma, personal communications).

Lack of sewage treatment and bacteriological standards have been linked to adverse health impacts on farm hands too. A study in Varanasi in the 1990s for instance showed that farm workers using untreated sewage showed high prevalence of diarrheal disease, helminthic infection and skin diseases. Examination of stool revealed high presence of Hookworm (41.7%), moderate presence of Roundworm (29.2%), Trichuristrichura (16.7%) and Giardia lamblia (33.3%). After setting up treatment facilities, prevalence of skin diseases were reduced from 42.5% to 6.2%, as monitored during the post-project period (Arunabha Majumder, personal communications). Similar findings were reported from sewage farm workers in Titagarh, West Bengal where disease prevalence over a period of 6 months showed high prevalence of diarrhoea (61.2%) and parasitic infection (Arunabha Majumder, personal communications).

Solutions are expensive

According to the CPCB study, one of the ways of achieving 100 per cent removal of coliform is to employ water purification processes, like chlorination, after primary or secondary sewage treatment (CPCB, 2008). The WHO, however, advises treating wastewater to nearly drinking water standards as economically unsustainable and epidemiologically unjustified. Also the danger with legal enforcement of standards that are not achievable is that they become debased (Johnstone and Horan, 1994). Keeping this in mind, CPCB sought to set the standards, not on entirely negating the associated health risks such as the USEPA standard, but based on the techno-economic feasibility of prevailing sewage treatment technologies to reduce coliform counts.

In October 2008, CPCB approved a maximum standard of 10,000 MPN/100ml for total coliform. The matter was forwarded to the environment ministry for notification, but in February 2009, the ministry, desiring more techno-economic information, suggested it needed closer scrutiny. The Indian Institute of Technology, Delhi was asked to look in to the matter. The Institute spent 3 years trying to study different technologies, including newer methods of sewage treatment such as sequential batch reactors, to understand the link between coliform and actual risk of pathogenic contamination based on different exposure rates. The IIT evaluation has postulated that since risks are based on ingestion of pathogens, the probability of pathogenic contamination for different coliform levels must be ascertained for different levels of exposure in different settings and seasons. On the basis of risk, the government must take a call on the acceptable risks. The study is to be finalised this year after broader consultations (A K Mittal, personal communications).

Urban India has the infrastructure to treat only 30 per cent of the sewage generated, as per the latest figures.Also, given the underutilized capacity of these plants, only 22 per cent of the sewage actually undergoes treatment. Reducing coliform requires advanced treatment technologies, which are missing in most basic treatment facilities in India. Conventional sewage treatment technologies employed in river action plans funded by the Centre since the mid 1980's serve primarily to meet standards for biological oxygen demand and suspended solids. Any coliform reduction in the range of two or three log reduction is incidental, and does not meet the CPCB standard proposed. It must be noted that tertiary treatment options include chemical-aided flocculation, sedimentation, use of activated carbon, and or chlorination, all of which add significantly to the treatment costs. This is a tough proposition given that even basic secondary treatment facilities are yet to be installed. While minimum or no health risk must be ensured, there must be cautious approach in utilizing chemical disinfectants to safeguard public health.

There are several non mechanized systems such as Oxidation Ponds, Duckweed Ponds, Lagoons, Constructed wetlands, and options of discharge to land (irrigation), which is suitable for dealing with coliform levels in municipal wastewaters. They are easier to maintain, and less costly in initial as well as maintenance costs. According to Soli Arceivala, former director of NEERI, such systems are, however, often avoided because of the following three typical reasons: 1) They use more land; 2) performance can be affected by climate and seasonal changes; 3) Unlike mechanized systems, performance guarantee cannot be given. It is up to the pollution control boards to accept this somewhat lesser performance in the winter months as inevitable with natural systems. Also, no great damage will occur to the environment, but much money will be saved by the country, and carbon emissions will be reduced if natural systems are employed (Soli Arceivala, personal communications). Land is undoubtedly an important resource, but availability is not restricted ubiquitously. Where land is not available, use of mechanized methods should be allowed, but on the provision that the electricity requirements for operating such systems be generated on site from a renewable source.

Treatment facilities in India have been found to remove a maximum of 99 per cent of the coliformcounts in sewage. But sewage contains coliform upwards of 10 million MPN/100ml, so even a 99 per cent removal, or a two log reduction, would not be enough to meet the WHO standards.A viable solution is the use of oxidation ponds. Herein the coliform reduction can be up to 6 logs, and meet the WHO standard, but it requires a retention period of 6-8 days, and therefore has a large land footprint, often not available in urban areas (Arunabha Mazumder, Personal Communications).

The guidelines issued by the WHO or USEPA would require setting up tertiary treatment infrastructure in all sewage treatment plants to achieve treated sewage to a high grade effluent, near potable standards.But given that most urban areas lack even secondary treatment, urban India may not be able toafford stringent standards, yet, and therefore policy must be guided by 'acceptable' risks. Most importantly, use of sewage for irrigation is a low cost method of disposal. This will reduce the burden on establishing capital intensive sewerage systems comprising sewer lines, treatment plants and disposal mechanisms. Sewage for irrigation must be incorporated in to India's pollution prevention strategy and 'acceptable' risks must be worked out to safeguard the interests of farmers and consumers.

Recommendations:

- There is a need to identify and map where sewage is being used for irrigation in India, in what quantity and with what quality.
- The idea is not to restrict farmers from use of partially treated sewage; this is not a viable solution, especially where it presents itself as the only viable option.
- Guidelines must be issued to preventuse of untreated sewage for the cultivation of fruits and vegetables, especially those to be eaten raw. These are most susceptible to contamination, and also happen to be the most commonly grown. Where treated sewage is used, bacterial standards must be set.
- Policy guidelines can recommend against sowing of crops that grow close to the soil such as lettuce and tomatoes, which are eaten without peeling or cooking.

- There is also a need to institute a preventive campaign; government can issue medication, such as de worming tablets, as a preventive for farm hands using wastewater as their irrigation source.
- In most cases, the use of chemical disinfectants to reduce the bacterial counts to zero risk levels is prohibitively expensive and may have an adverse effect on the environment. The government must promote safe practices for farmers (use of boots/gloves) so that infection agents do not infiltrate skin.
- There is need to engage media and health workers to start an education campaign for farm hands and disseminate information on preventions and cures.
- Impact assessmentsneeds tobe carried out to gauge and link effects on soil, possible groundwater contamination, and food quality characteristics.Field studies such as in Haroonabad (Pakistan), revealed that even after 35 years of wastewater irrigation, the soil did not have heavy metal concentrations above international stipulated standards (IWMI, 2003). But this needs to be monitored periodically.
- Often peri-urban farming meets a city's vegetable demand and is sold within 3 days. In several Asian cities wastewater agriculture accounts for more than half the vegetable demand (IWMI, 2003). The transit period of sewage irrigated crops must be ascertained, and regulated.
- Another added risk is that fruits and vegetables are often washed in dirty water with high bacteria counts, which increases health risks.
- It is suitable that coliform standards in India are being developed at the outlet of a sewage treatment plant. This is important given that often treated sewage is used, for a variety of purposes, prior to confluence with a river or lake. The travel time and potential improvement in water quality en route, often to the extent of a two log reduction, also needs to be factored in to the standards.

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