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Consolidated Reply

Query: Setting Norms for and Treating Polluted Irrigation Water - Experiences; Advice

Compiled by Pankaj Kumar S. and Gopi N. Ghosh, Resource Persons; Ramya Gopalan and T. N. Anuradha, Research Associates
29 March 2007

From Abhay Kumar, Toxics Link, New Delhi
Posted 13 February 2007

I work for Toxics Link, an NGO which collects and shares information about the sources and dangers of poisons in our environment and bodies, and works for clean and sustainable alternatives for the same. We are currently working on a DFID funded project on monitoring contaminated irrigation water and its implications for food safety along with University of Sussex, UK; Banaras Hindu University and Delhi University. For details please visit www.toxicslink.org or www.pollutionandfood.net.

Under this project, we have found that with increasing shortage of fresh water, more and more polluted water is being used to irrigate food crops, especially in peri-urban areas. Such contamination can have serious implications for health and livelihoods of consumers of the produce. Various interventions can either reduce pollution at source, or in some cases, ameliorate the impact of pollution. However, such interventions will require cooperation between local communities and various agencies. It will also require an enabling policy and regulatory regime.

In the above context, I request members to respond to the following questions:

- What are the different techniques to treat irrigation water having heavy metals and other chemical pollutants to bring them within permissible limits?
- What is the process to set up tolerable limits for these contaminants - both for irrigation water as well as for food crops?
- What could be the legal, policy and economic instruments to enforce such standards for heavy metals and other chemical pollutants in irrigation water?

The discussions will help us understand the nuances of the issue, and work towards suitable policy and technological interventions to tackle the above problem.

Responses were received with thanks from:

1. **Srikanth, WaterAid India, New Delhi**
2. **Mrinalinee Vanarase, Ecological Society, Pune**
3. **G. Misra, Directorate of Economics and Statistics, Port Blair**
4. **K. V. Peter, Kerala Agriculture University, Thrissur**
5. **Digbijoy Bhowmik, GoI-UNDP Project 'National Strategy for Urban Poor', New Delhi**
6. **Debadutta K. Panda, MPAssociates, Bhubaneswar**
7. **Muhammad Jahangir, Drinking Water-Pakistan Google Group, Islamabad**

Further contributions are welcome!

Summary of Responses

Responding to the query on setting norms for and treating polluted irrigation water, members discussed various treatment techniques and suggested possible institutional and other interventions to address the problem.

Members acknowledged that although **untreated wastewater** is often the major source of irrigation and nutrients especially in lean seasons, it engenders heavy metal and chemical pollution of surface and groundwater for downstream communities. The problem is especially acute in peri-urban areas due to the increased industrial pollutant load. They noted that the issue has not received the required attention due to a paucity of studies establishing the negative health effects of consuming food grown in polluted water.

Discussants pointed out that while technology for treating wastewater is available, the product quality is not standardized and a gap remains between what is available in developed countries versus the developing world. Moreover, raising the acceptable levels of wastewater exponentially raises the cost of operation, hardware and technology. Ensuring that the wastes are treated before they are discharged as effluents is therefore a more affordable option, felt members. In this context, respondents cited several preliminary steps that may be taken to effectively limit contamination:

- Locating industries away from habitations
- Requiring industries to install water purification equipment in their plants prior to being granted an operating licenses
- Adding lime to sewage sludge to prevent accumulation of pH dependent metals
- Redefining the duties and responsibilities of Central Pollution Control Board and increasing its efficiency

The group referenced the Pollution Control Board's water use classification and suggested various **low cost eco-friendly technologies** for treating polluted irrigation water. One technique members recommended was root zone technology, a low-cost and maintenance free option functioning effectively in about 3,500 sites worldwide. The technique uses the capacity of plants (especially certain reeds – hence also called reedbed technology) to absorb contaminants and structurally modify them for treating water. Evapo-transpiration losses, although present, are bearable compared to the ill-effects of using contaminated water. With suitable modifications, the technique is low cost, maintenance-free and can overcome the constraint of land area. An organization from **Maharashtra** has experience in utilizing root zone systems for treating sewage water.

Other techniques members discussed for wastewater treatment were:

- Using filterants for removing silt, microorganisms and heavy metals
- Ozonisation – the use of ozone for disinfecting water
- Using charcoal to clear impurities
- Biosorption - the removal of toxic metals from wastewaters using metal binding capacity of various biological materials such as algae, water hyacinth, etc.
- Phytoremediation - use of plants to remove pollutans from water
- Project 5 – a low-cost technique developed by an agency in Lucknow

Additional research highlighted other possible technologies such as duckweed-based stabilization of ponds; using drumsticks seeds as a natural coagulant to purify water; and employing the absorption capacity of vetiver grass to bring the amount of nutrients, agrochemicals and heavy metals to acceptable levels.

In addition, members also mentioned several steps that could be taken to mitigate the impact of using polluted wastewater to irrigate crops such as:

- Using wastewater in peri-urban areas to irrigate floriculture crops rather than food crops
- Pushing for legislation banning the cultivation of leafy vegetables in contaminated waters
- Using water judiciously, especially in urban areas, to reduce amount of wastewater produced
- Treating waste and polluted water before releasing into rivers

Further, respondents suggested three innovative ideas for addressing the issue of polluted irrigation water. One suggestion was to shift from a **regulatory to an incentive based regime**, thereby reversing the 'polluter pays' principle and ensuring 'remunerative compliance', that is providing an incentive to an industrial unit for keeping natural resources usable. The 'incentive' would offset capital and environmental costs of finding alternative water sources for irrigation.

Another method members suggested was to use **cluster grouping** of industries in an 'industrial estate' to share a Common Effluent Treatment Plant and to maintain a corpus for obtaining a desired effluent quality. This would ensure the stability and sustainability of the costs of environmental management. The use of universal standards like the ISO 14000 series could then be introduced at the cluster level, and be maintained for modern industrial estates and Special Economic Zones.

A third method respondents recommended was for industrial estates (or standalone units) to **'cycle' water usage**, that is plug into the hydrological loop and source recycled water from other sources. Citing an example from **Maharashtra** members explained how the city was partially treating its wastewater to use in its thermal power unit. This lowered the cost of purchasing raw water from a groundwater source. Similarly, naturally occurring water with medium to high total dissolved salts (TDS) could be used by some industrial units which would then discharge effluents with an even lower TDS. Members suggested that the State Pollution Control Boards and Water Authorities could make this part of a proactive approach for dealing with wastewater, and take both a facilitative and a punitive approach.

Finally, members stressed the vital importance of running **awareness campaigns** on the dangers of using polluted water to irrigate food crops. These campaigns need to emanate from solid scientific research and to involve various stakeholders including public health institutions and state pollution control boards. The campaigns also need to extend into peri-urban areas since these areas are the major contributors to pollution.

In conclusion, respondents reiterated the need for ex-ante precautionary measures to ensure minimal wastewater generation. A focus on treatment and quality assurance of the production process will obviate the need to look for technologies to treat water at the end of the pipeline. This would be a more sustainable and affordable solution to the problem, felt members.

Comparative Experiences

From Ramya Gopalan, Research Associate

Pondicherry

Root Zone Treatment Systems in Auroville
Horizontal planted filters, also called constructed wetlands or root zone treatment systems have been developed for recycling domestic wastewater from small individual households, communities and small industrial units producing effluent with similar characteristics to domestic wastewater. At present, the town Auroville successfully operates nearly forty treatment systems for recycling domestic wastewater under their decentralized wastewater treatment systems.

Tamil Nadu

Challenges of Industrial Effluent Irrigation
In Mettupalayam, industries were disposing of their effluents on land. Farmers from adjacent farmlands complained of polluted shallow open wells and increased salt content in their soil. Continuous disposal of industrial effluents also led to groundwater contamination. To address the problem, a study was conducted, which showed that adoption of precautionary measures, regulation of water quality, involvement of concerned authorities, and community monitoring institutions could mitigate the problem.

International

Pakistan

Advantages vs. Disadvantages of Using Untreated Urban Wastewater in Haroonabad
A study was conducted in nine farmer's fields to asses the pros and cons of farms using wastewater for irrigation. It examined the water and nutrient applications and soil and groundwater quality. The main benefit for farmers using wastewater was a reliable water supply, and the nutrients it contains. However, farmers and their families experienced negative health impacts. The study emphasized the need to lower health risks and increase the socioeconomic and environmental benefits of using untreated wastewater.

Related Resources

Recommended Documentation

From Digbijoy Bhowmik, GoI-UNDP Project 'National Strategy for Urban Poor', New Delhi

Biosorption of Heavy Metals
N. Ahalya, T.V. Ramachandra and R.D. Kanamadi; Centre for Ecological Sciences (IISc), Bangalore
http://www.ces.iisc.ernet.in/energy/water/paper/biosorption/biosorption.htm

> *Details biosorption as a low cost, effective treatment method of using biological material to remove heavy metals from aqueous effluents*

A Citizen's Guide to Phytoremediation
US Environmental Protection Agency (EPA), April 2001
http://www.clu-in.org/download/citizens/citphyto.pdf (Size: 88 KB)
Provides a description on approaches to clean up contaminated water using Phytoremediation

Project 5
Environmental Research Laboratory, Rediff.com
http://members.rediff.com/saeserl/project5.html
Discusses a cost-effective water purification technology for rural household in regions affected by iron, lead and other heavy metal contamination

Root Zone Treatment System *(from Mrinalinee Vanarase, Ecological Society, Pune)*
Central Pollution Control Board, New Delhi
http://www.cpcb.nic.in/pciiiihandbook.htm
Central Pollution Control Board provides a handbook on the application and assessment of Root Zone Treatment System

Wastewater Treatment and Use in Agriculture- FAO Irrigation and Drainage Paper 47 *(from Srikanth, WaterAid India, New Delhi)*
M. B. Pescod; FAO Corporate Documentary Repository; 1992
http://www.fao.org/docrep/t0551e/t0551e00.htm
Details wastewater characteristics, quality parameters and guidelines for agricultural use of wastewaters and also provides case studies of wastewater treatment and use

Moringa Oleifera as a Natural Coagulant *(from K. V. Peter, Kerala Agriculture University, Thrissur)*
J.P. Sutherland *et al,* Affordable Water Supply And Sanitation, 20th WEDC Conference Colombo, Sri Lanka, 1994
http://www.lboro.ac.uk/departments/cv/wedc/papers/20/sessioni/sutherla.pdf (Size: 31 KB)
Discusses the tree's uses of all its parts especially for their pharmacological, nutritional and purifying water properties and for its further use as a natural fertilizer and livestock feed

From Ramya Gopalan, Research Associate

Waste Water Recycling
The Auroville, Pondicherry
http://www.auroville.org/research/water_recycle.htm
Provides details on the adoption of root zone treatment system for the recycling of waste water under the Decentralized Wastewater Systems

Duckweed Based Wastewater Treatment System
Parivesh, Newsletter from the Central Pollution Board
http://www.cpcb.nic.in/r&d-cpcb/ch7-20603.htm
Central Pollution Control Board provides information on the application and assessment of Duckweed Based Waste Water Treatment System

Urban Wastewater: A Valuable Resource for Agriculture- A Case Study from Haroonabad, Pakistan
Wim van der Hoek *et al.*; International Water Management Institute (IWMI) Colombo; 2002
http://www.iwmi.cgiar.org/pubs/pub063/Report63.pdf (Size: 477.9 KB)
Documents costs/benefits of using untreated urban wastewater, obtained by monitoring a group of 20 wastewater and non-wastewater farmers over a one year period

Recycling Realities: Managing Health Risks to make Wastewater an Asset

Water Policy Briefing, Issue 17; February 2006
http://www.iwmi.cgiar.org/waterpolicybriefing/files/wpb17.pdf (Size: 318.7 KB)

Gives recommendations for safer and more sustainable use of wastewater without relying on non-affordable treatment technologies alone, in harmony with WHO guidelines

Treating Irrigation Water
Texas Greenhouse Management Book
Click here to view link

Discuses Texas where producers of nursery and greenhouse crops experience a variety of water quality problems specifically in the three areas of pH, alkalinity, and soluble salts

Vetiver System Ecotechnology for Water Quality Improvement and Environmental Enhancement
Meeting Report, News, Current Science, Vol. 86, No. 1; January 10, 2004
http://www.ias.ac.in/currsci/jan102004/11.pdf (Size: 150.3 KB)

Discuses this low cost, effective system that offers proven solutions for soil and water conservation, wastewater treatment, and many other environment-friendly applications

The Role of Vetiver in Controlling Water Quantity and Treating Water Quality: An Overview with Special Reference to Thailand
Narong Chomchalow; 2003
http://www.vetiver.com/THN_vetiver_water.pdf (Size: 363.9 KB)

This paper discusses how vetiver can control the quantity of water and treat water quality through simple methods, using low cost technology

Ground Water Pollution and Emerging Environmental Challenges of Industrial Effluent Irrigation: A Case Study of Mettupalayam Taluk, Tamil Nadu
Sacchidananda Mukherjee and Prakash Nelliyat; Madras School of Economics, Working Paper 7; March 2006
http://www.mse.ac.in/pub/mukpra.pdf (Size: 1.3 MB)

Captures environmental and socio-economic impacts of industrial effluent irrigation in industrial locations of the chosen Taluk via primary surveys and secondary information

Recommended Organizations

The National Cleaner Production (NCP) C Program, UNIDO, New Delhi *(from Digbijoy Bhowmik, GoI - UNDP Project 'National Strategy for Urban Poor', New Delhi)*
55 Lodi Estate, New Delhi, 110003; Tel.: 91 1124643484; Fax: 911-124620913; office.india@unido.org; http://www.unido.org/doc/5133?language%5fcode=en

Aims at building national CP capacities, dialogue between industry and government and enhancing investments for the development of environmentally sound technologies

Central Pollution Control Board, New Delhi *(from G. Misra, Directorate of Economics and Statistics, Port Blair)*
Ministry of Environment and Forests, Government of India, Parivesh Bhawan, East Arjun Nagar, New Delhi 110032; Tel.: 91-11-2305792/23303717; cpcb@nic.in; http://www.cpcb.nic.in/standard32.htm

Identified as the central body responsible for setting and enforcing standards for treating polluted irrigation water

National Innovation Foundation, IIM, Ahmedabad *(from K. V. Peter, Kerala Agriculture University, Thrissur)*

P.O. Box 15051, Bungalow 1, Satellite Complex, Jodhpur Tekra, Premchand Nagar Road, Vastrapur, Ahmedabad 380015, Gujarat; Tel.: 91-79-2673-2456/2095/55410805/6; Toll Free No.: 1800-233-5555; Fax: 91-79-2673-1903; http://nifindia.org/presentation/index.htm

Recommended for maintaining registry of grassroots innovations for making water drinkable, as well as other sectors - plant protection, cultivation practices, energy and water management

IORA for Environmental Solutions, Pune *(from Mrinalinee Vanarase, Ecological Society, Pune)*
901 Purushottam Apartments, Lane 3, Off Bhandarkar Road, Pune 411004; Tel.: 91-20-25679028
http://www.iora.in/main.htm

Recommended for their experience in sewage water treatment using Root-Zone Treatment System (RZTS)

Related Past Consolidated Reply

Treatment of Wastewater for Reuse, from K. A. S. Mani, APFAMGS, Hyderabad (Experiences).
Water Community. Issued 14 March 2006

Explores range of approaches in wastewater treatment covering small household level treatment devices, middle range technologies and large intensive solutions

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Responses in Full

Srikanth, WaterAid India, New Delhi

It is a well known fact that untreated wastewater contains heavy metals and myriad chemicals, especially in peri-urban areas because of the impact of industries. All major cities have this problem in India, and this also the case in Africa. Classic examples are River Musi in Hyderbad, where bulk of forage and green vegetables supplied to city comes from sewage farms in peri-urban areas contaminated by industrial wastes. The situation in all other major cities is no better including in Delhi.

Many a times it is a livelihood issue and cannot be avoided, since such wastewater provides nutrients and is often the sole source of water during lean periods. So far this has not been viewed with seriousness because no health impact studies has been carried out in India which have proved conclusively the negative impact on health of community consuming these food crops. Most research reports currently speak about permissible limits and stop at that.

To answer your question, the solution to this problem would come only if proper awareness is created with the support of solid scientific research involving various stake holders, including public health institutions and state pollution control boards. ISI guidelines are already in place for release of effluents into rivers and tanks to prevent surface and ground water contamination, but this is seldom implemented by the agency responsible to so. I have the following suggestions:

1. Studies have shown that more heavy metals accumulate in sludge than in irrigated water, therefore liming of sewage sludge prevents mobility of metals since they pH dependent.
2. FAO has set up guidelines for using wastewater for cultivation with special reference to coliform and helementhic parasites
3. It may be better to use waste water peri-urban areas for Floriculture than for food crops.
4. Leafy vegetables accumulate more metals than others, therefore cultivation of these in contaminated waters should be banned through effective legislation.

Looking forward to some more solutions from other members' experience.

Mrinalinee Vanarase, Ecological Society, Pune

Regarding your query of treating contaminated irrigation water, the best possible solution I have known is root zone technology. The capacity of plants to absorb contaminants and structurally modify them can be effectively used in treating water for irrigation. In this, there will be losses due to evapo-transpiration but these are bearable compared to using contaminated water. Certain reeds perform this function very effectively, which is why it is also called reed-bed technology.

Many a times, land area is taken as a constraint in applying root-zone. However, it can also be done using suitable variations in design and type. Our organisation has installed one root-zone in Maharashtra on sewage water and it gives wonderful results. There are about 3500 root-zone systems effectively functioning all over the world. The technology is low-cost and maintenance free (which is why it is not popular, perhaps!). It has many other ecological benefits, details of which I can provide, if anyone is interested.

G. Misra, Directorate of Economics and Statistics, Port Blair

We all know that most pollutants come from industries. Generally, industries just let all their waste to flow onto roads/ canals/ rivers or in open fields. Sometimes the whole area becomes polluted. I knew one area on the Kanpur-Lucknow road near Unnao, which we cannot pass without covering our noses. The effluents from neighbouring factories have polluted both the groundwater and surface area in this place.

I have the following suggestions:

1. There are various processes for removing pollutants from water. Firstly, we should learn to use water judiciously, especially in metros and urban areas. For example, Delhi should stop pouring contaminated water into the Yamuna. The city should treat its waste and clean it of all pollutants, only after which it may be released into the Yamuna. Residents of Delhi should be taxed accordingly.
2. In traditional canal systems, ponds and canals, water hyacinth and other live organisms may be introduced so that water can be treated naturally. I feel priority should be given to methods using minimum chemicals. A few plots have come up along the Yamuna river in Delhi, where first the waste is kept for few days and later allowed to flow into the river.
3. It should be made obligatory for industries to first install water purification technology in their plants, only after which the license and permission to start the industry should be given. Industrial area need to also be located far from habitations, and need to treat effluents from before letting it into water bodies.
4. The Central Pollution Control Board needs to be made more efficient and its duties and responsibilities need to be re-looked at.
5. Awareness campaigns in the peri urban areas need to be done on the issue, since peri-urban are major contributors to pollution.

K. V. Peter, Kerala Agriculture University, Thrissur

Water is life. There are many innovations to transform impure water to potable and drinkable water. There are good number of filterants to remove silts, microorganisms and also heavy metals. Ozonisation is another recent technique. In villages, charcoal is used to clear off impurity. Dried drumstick seed is also a good filterant. The National Innovation Foundation located at IIM Ahmedabad maintains a registry of grassroots innovations for making water drinkable.

Digbijoy Bhowmik, GoI - UNDP Project 'National Strategy for Urban Poor', New Delhi

You may want to visit the following sites for technologies available for heavy metal waste removal:

http://www.ces.iisc.ernet.in/energy/water/paper/biosorption/biosorption.htm - Biosorption - a well known but low scale method for removal of heavy metallic pollutants.

http://www.clu-in.org/download/citizens/citphyto.pdf (Size: 88 KB) - Phytoremediation - also a well documented method.

http://members.rediff.com/saeserl/project5.html - a product provider for similar technologies (you may want to check with some of the other clients of this firm).

There are quite a few considerations that can be looked at in this context.

1. **Shift from restrictive regulatory regime to incentive based regime** - A pure regulatory and inspector-based regime is UNIVERSALLY bypassed - be it for industrial safety, health safety or anything that requires a non-remunerative compliance. This stems from the fact that there is a penalty for non-compliance, but almost no reward for compliance. Thus, an approach could be to looked at remunerative compliance, that is, there is an incentive to the industrial unit for adopting ways and means for keeping natural resources usable. This could be offset against the capital and environmental costs of finding an alternative source for water that can be used for irrigation. In other words, this is a reversal of the "polluter pays" cycle. I daresay here that this would probably benefit the Small and Medium Enterprise sector more than the large scale sector.

2. **Industrial estate/ cluster grouping and siting** - Clusters usually tend to be more stable in terms of having sustainable costs of environmental management, with multiple units sharing Common Effluent Treatment Plants and maintaining a corpus for maintaining desired quality of discharged effluent. Modern industrial estates and Special Economic Zones could (and should) maintain something like the ISO: 14000 series standards at the cluster level, apart from individual unit level.

3. **'Cycling' water usage**: Industrial estates (or standalone units) are part of the hydrological loop that forms in any human settlement, with certain qualitative and quantitative requirements. However, there is always room for making every drop abstracted from the source work at least twice. In Nagpur, Maharashtra, city level wastewater is being partially treated for use in a thermal power unit, which has lowered its cost of buying raw water from a ground source. On the flipside, water with naturally occurring medium to high TDS content can be used by some units, whose treated effluent has a much lower TDS content, and thus can be appended to areas of usage where ground water could not be previously used (e.g. Mewat, Haryana). Parastatals such as the State Pollution Control Board and State Water Authority can make this part of their proactive approach for dealing with the problem that has both a facilitative as well as punitive dimension to it.

4. **Affiliations to global programmes** - such as the National Clean Production Centers Program of the UNIDO (see http://www.unido.org/doc/5133?language%5fcode=en) which propagate usage of clean technologies.

Debadutta K Panda, MPAssociates, Bhubaneswar

According to the pollution control Board, the water use classification is,

Class "A" - Drinking water sources without conventional treatment but after disinfection

Criteria:

I. Total Most Probable Number (MPN) of coliform organisms per 100 ml shall be 50 or less.
II. pH - between 6.5 to 8.5
III. Dissolved Oxygen - 6mg/liter or more
IV. 5-day Biochemical Oxygen Demand at 20 ^{o}C - 2mg/liter or less

Class "B" - Outdoor bathing (Organized)

Criteria:

I. Total MPN/100 of coliform organisms shall be 500 or less.
II. pH - between 6.5 to 8.5
III. Dissolved Oxygen - 6mg/liter or more
IV. 5-day Biochemical Oxygen Demand at 20 ^{o}C - 3mg/liter or less

Class "C" - Drinking source with conventional treatment and disinfections

Criteria:

I. Total MPN/100 of coliform organisms shall be 5000 or less.
II. pH - between 6.5 to 9
III. Dissolved Oxygen - 4mg/liter or more
IV. 5-day Biochemical Oxygen Demand at 20 ^{o}C - 3mg/liter or less

Class "D" - Propagation of wildlife and fisheries

Criteria:

I. pH - between 6.5 to 8.5
II. Dissolved Oxygen - 4mg/liter or less
III. Free ammonia (as N) - 1.2 mg/liter or less

Class "E" - Irrigation, industrial cooling, controlled waste

Criteria:

I. pH - between 6 to 8.5
II. Maximum Electrical conductivity at 25 ^{o}C – 2250 micro mhos/cm
III. Maximum Sodium absorption ratio - 26
IV. Maximum Boron level - 2 mg/liter

Muhammad Jahangir, Drinking Water-Pakistan Google Group, Islamabad

I am happy that this issue has generated a lively discussion.

All of us know that in South Asia, we are passing on our untreated domestic and industrial waste to ground and surface water in downstream locations.

This is has a genuine reason as well. The technology for treatment is available, but leaves a wide gap between the product quality in the developing and developed world. Also, the costs of operation, hardware and technology for raising the level of acceptable standards of treated water (which in most cases is very high in developed countries), rise exponentially.

I think that rather than treating the polluted water at the end of the pipe line, we need to focus on quality assurance in treating our wastes to an affordable level (a difficult decision to take) and then allowing it to flow downstream.

Many thanks to all who contributed to this query!

If you have further information to share on this topic, please send it to Solution Exchange for the Water Community at se-wes@solutionexchange-un.net.in or Food and Nutrition Security Community at se-food@solutionexchange-un.net.in with the subject heading "RE: [se-wes][se-food] Query: Setting Norms for and Treating Polluted Irrigation Water - Experiences; Advice. Additional Reply."

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