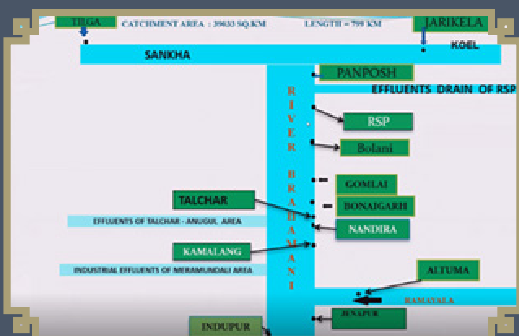
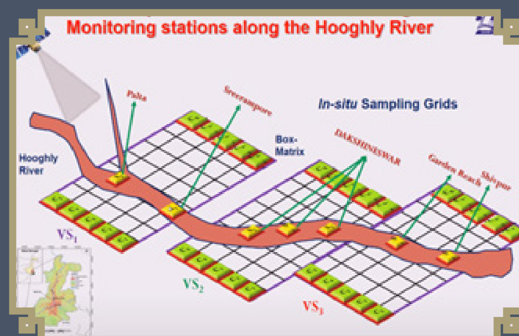
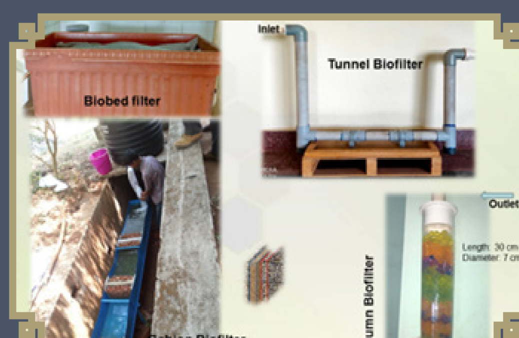
Technical Bulletin No. 87

Recommendations of Brainstorming Workshop on "Water Quality Issues and Policy Guidelines in Agriculture and Aquaculture"







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MESSAGE

Population growth, elevated living standards, excessive exploitations of groundwater and climate changes, stress on clean water availability and supply pose threat on environment and every living organisms. Managing water scarcity is a global challenge that affects food production, the environmental, social-economic and political cornerstones of human existence on earth. Effluent reclamation and reuse provides opportunities to efficiently utilize water and maintain the quality of the existing fresh water resources.

Under prime water quality concerns, the salinity prevent the uptake of water by plants causing reductions in crop yield. Injudicious use of fertilizers in agriculture causes water pollution. Excess nutrients causeeutrophication, hypoxia and algal blooms in surface water bodies and coastal areas. Such quality parameters not only affects agricultural productivity but also the fish production and its quality. Moreover, pesticide and herbicide contamination in groundwater and surface water bodies in intensive agricultural regions are adding woes to the water quality issues.

The National Water Policy mostly focussed on the quantity of the resource whereas the quality of water is a major threat to environment, ecology and human health. With the increased water scarcity, the poor quality water is being used in agriculturewithout any specific guidelines and regulations. The recommendations of this brainstormingworkshop will pave the pathway to assess and mitigate the risk associated with use of poor quality water in agriculture and aquaculture besides formulation of stringentand integrated policy guidelines.

(S.K. Chaudhari)

PREFACE

Freshwater is crucial for agriculture and food production, is vital for survival of humans in the form of drinking water, and necessary for industrial use as well as for recreation. The sources of freshwater commonly used include groundwater accessed from dugwells and tubewells and water accessed from surface water sources such as rivers, lakes, ponds and streams. However, the quality of freshwater is deteriorating rapidly due to increasing pollution and contamination due to human interventions. Pollution is mainly caused due to human activities, whereas contamination can be human induced or occur naturally in the environment either through 'point source' pollution or by 'non-point source' pollution. Poor sewage disposal mechanisms lead to serve as reservoirs of microbial contamination. Groundwater and surface water resources in India are highly polluted due to presence of fluoride, arsenic, nitrates, iron, and heavy metals as well as due to leaching of harmful pesticide and fertilizer residues. Toxins from untreated industrial wastes and landfills as well as bacterial contaminants from the surface soil and water sources can also contaminate water resources.

Use of poor quality water in agriculture and aquaculture facilitates the contaminants to enter the food chain, which in turn pose threat to human and environmental health. The concern is to mitigate the risk associated with use of poor quality water in agriculture and aquaculture and to maintain water quality for sustainable food production. A brainstorming workshop was organized on "Water Quality Issues and Policy Guidelines in Agriculture and Aquaculture" on 13th January 2023 with 25 Panelists from different Institutions (Central - State - Local Governments) and 54 participants in total. The recommendations of the brainstorming sessions are published for its future use by researchers, stakeholders, administers and policy makers.

– Authors

CONTENT

BACKGROUND

Water being one of nature's most precious resources is essential for survival, livelihood, food security and sustainable development. It is indispensable to ensure the security of the world's food supply and a large portion is used in agricultural production. India is endowed with 18 per cent of the world's population but possesses only 2.4 per cent of the planet's land area and 4 per cent of its renewable water resources. Further, the availability of utilizable water will be reduced in future. Consequently, the chances of escalated water disputes among various stakeholders will be more frequent due to the competing water demands by increasing population. The influence of climate change will also aggravate the situation. On the top of that, inadequate awareness of the quality, value, and scarcity of water leads to wastage and mismanagement of the precious resource.

The interactions between water quality and agriculture or aquaculture are manifold and complex. Large irrigation schemes contribute to global food security, particularly in arid areas, but it has also led to land and water salinity problems. Both expansion and intensification of agriculture with increased and non-judicious use of fertilizers and pesticides have degraded the quality of water in rivers, lakes and marine water bodies. Intensification of livestock farming systems increased the potential transmission of pollution from both animal waste and fodder production resulting in eutrophication of freshwater bodies.

Water scarcity has driven millions of farmers worldwide to irrigate with marginal quality water such as wastewater from urban or industrial areas or saline water. Protecting the environment and human health with minimum risks and maximizing the benefits, while using such marginal water, possesses an enormous challenge. The use of naturally occurring arsenic-laden groundwater in agriculture necessitates special attention.

These examples elaborate the complex interactions between the agriculture and water quality. The share of water resources and its quality is deteriorating day by day that requires attention and a systematic study to develop a suitable methodology and policy guidelines in convergence with all the stakeholders associated with irrigation water.

An attempt has been made to brainstorm with experts from different research organizations, central and State organizations to chalk out the present status of water quality issues, interaction of water quality with agriculture and aquaculture, health impacts, monitoring systems and available technologies to frame policy guidelines so as to maintain the water quality for agriculture and aquaculture use. Brainstorming workshop was organized to deliberate on 1) Water quality issues and risk assessment, 2) Impact of poor quality water on natural resources, 3) Technological options to mitigate risk associated with water quality issues, and 4) Policy guidelines for safe water use in Agriculture and Aquaculture. Prime objective was to take cognizance of the existing water quality issues and related risks in agriculture and aquaculture, to review and prioritize different technological options and propose a framework for creation of a system of laws and Institutions for developing a plan of action under a unified national perspective.

Water quality issues and risk assessment

- Water quality and quantity are interlinked and need to be managed with an integrated approach. Nowadays, where there is water scarcity, maintaining water quality of available water resources is the absolute need.

- Central Water Commission (CWC) monitors water quality covering all the important river basins of India through a three-tier laboratory system for analysis of the physico-chemical and biological parameters of the water. Presently only five Level-III laboratories are operational where 41 parameters including heavy metals, toxic parameters and pesticide residues are analysed. It was recommended for setting up of more numbers of Level –III laboratories to monitor the toxic parameters for all polluted river systems.

- Water Information Management System (WIMS) may be used for water quality management aspects like pollution from urban areas and industries, organic point source of pollution, point source pollution through hazardous substances, pollution from agriculture and non-point source pollution through nitrogen, phosphorous and pesticides.

- Anthropogenic sources of pollution like Arsenic (As) containing fungicides, pesticides and herbicides, metal smelters, by-products of mining activities, chemical wastes, by-products from refining of Pb, Zn and Cu, fertilizer industry, pesticide manufacturers, cadmium–nickel batteries need to be restricted.

- Toxic metallic elements containing effluents from polluting industries need appropriate treatment as per the norms before its disposal to fresh water bodies. Industrial pollution of river system is a great concern which needs targeted interventions.

- Promotion of effective pollution control laws, regulations, and its efficient implementation is recommended. Identification of point source pollution to prevent the industrial and urban waste disposal and intervention at the source to maintain water quality are important. Stringent Government policy and monitoring for effluents discharged from polluting sectors into river basins viz. Ganga, Ghagra, Rapti, Ramganga, Subarnarekha, and Thungabhadra etc. need to be implemented.

- It was recommended to investigate the speciation of the toxic metals e.g. Chromium (Cr^{+3} & Cr^{+6}) and Arsenic (As^{+3} & As^{+5}) in Indian rivers. The metal fractionation study should be carried out in the river sediments to identify the inorganic load (Metal Load).

- Contamination of Cr, Zn and Pb were observed in fish and prawn in lower stretch of Ganga River. Pb (6 mg/kg), Zn (~200 mg/kg), and PCP (Triclosan up to 1 mg/kg) were reported in fish of Gomti River. Arsenic contamination in ponds at Basirhat and Bhaduria, North 24 Parganas district, West Bengal was reported.

- Maintaining water quality in the fishpond from breeding to adult stage is challenging and there is a need to incorporate water quality factor in water budgeting analysis.

- Changes in some existing aquaculture practices are required to make the system sustainable and to avoid instability in production, pollution, flooding, erosion and poor water quality. Maintenance of water quality leads to profitable and sustainable aquaculture system.

- Wetlands in Eastern part of Kolkata, West Bengal is the world's largest sewage water based aquaculture system. The wastewater generated from industries, domestic sewage water is treated naturally leading to increase of the fish production of the system.

- Asian rivers account for about 81 % of riverine plastic wastes comprising of macro (>25 mm), meso (5-5 mm), micro (1-5 mm) and minimicro/nano (1µm-1 mm) plastics. These plastics adversely affect the growth of the fish. Micro-plastic pollution of water bodies, affecting aquaculture, needs special attention.

- Salinity influences the ionic balance in fish. Asian seabass can tolerate salinity ranging between 0-33 ppt, whereas the salinity tolerance of cobia, pompano, snappers and groupers range between 15-35, 5-35, 15-33 and 10-33 ppt, respectively. Optimum salinity for Asian seabass, cobia, pompano, snappers and groupers are 15, 25, 15, 25, 20 ppt, respectively. Selecting suitable fish for marine culture as per the salinity may reduce stress and enhance production.

- Water temperature, turbidity, salinity, pH, dissolved oxygen, ammonia, nitrates, nitrites, phosphates and algal blooms are some of the important parameters which require regular monitoring for sustainable fish farming.

- Optimum temperature depends on the type of cultivable species i.e. 26-32^{0}C for most tropical species. The growth of fish is highly affected due to temperature fluctuations. Extreme temperature-induced stress affects metabolic activities resulting in poor growth and health of fish. Selection of fast growing fish species and avoidance of the months with unsuitable temperature are better options for marine aquaculture.

- Excess of phosphorous in the water leads to algal blooms including diatoms, cyanobacteria and dinoflagellates. Water quality in pond, cage can be maintained through periodic exchange of polluted water with good quality water

- Detection of requisite concentration threshold of contaminants in agriculture and aquaculture is desirable from biological and environmental perspective. Alternative tool for monitoring like chemosensing is a viable and powerful option for analyte detection. Chemosensors and molecular probes can be developed for various targeted metal ion contaminants.

- Central Pollution Control Board of India has 33 Real Time Water Quality Monitoring (RTWQM) stations on river Ganga and its distributaries in three states viz. Bihar, Jharkhand and West Bengal. More numbers of RTWQM stations with facilities for estimation of toxic metals, pesticides and herbicides are required for every State to map the pollution in a better way.

- To assess the impact of Sewage Treatment Plants (STPs) and Gross Polluting Industries (GPIs) on nearby monitoring of groundwater quality to be carried out on regular frequency i.e. on quarterly basis at STP premises and annually at GPIs premises. The parameters viz. colour, pH, EC, COD, TSS, TDS, Cl^-, alkalinity, total hardness, NO_2^-, NO_3^-, PO_4^{-3}, SO_4^{-2}, F^-, NH_4^+, Na^+, K^+, Ca^{+2}, Mg^{+2}, trace/heavy metals (As, Co, Cu, Cd, Cr, Fe, Pb, Mn, Ni, Se, Sb, V, Zn) and biological parameters like total coli forms, faecal coli forms need to be monitored.

- It was also recommended to show-cause the non-complying industries pertaining to effluent discharge rules and regulations and their closures may increase the compliance.

- Technological interventions like installation of chemical recovery plant (CRP) in place of chemical digesters in agro based industries and upgradation of ETP (Effluent Treatment Plant) system and process technologies like fibre recovery system with enforcement of zero liquor discharge, may reduce the fresh water requirement, which, in turn, will reduce the wastewater discharge and BOD load.

- All STPs to be operational as per the Ministry of Environment, Forest and Climate Change notification dated 13-10-2017, regulation. Drains to be monitored on quarterly basis for physico-chemical and biological parameters including heavy metals, pesticides and organics.

Impact of poor quality water on natural resources

- Indiscriminate and injudicious use of fertilisers, pesticides and herbicides is rampant in India that pollutes the surface water posing threat to the environment, aquaculture ecosystem and public health. To understand the extent of variability in water quality, there is a need of spatio-temporal variability mapping using interpolation methods and development of riparian zones.
- It was also recommended to use integrated sensing devices and IoT-enabled systems through development of mobile apps for acquisition, analysis and documentation of water quality parameters in geospatial format.
- Concept of total maximum daily load (TMDL) which decides the maximum load to be discharged based on the existing water quality need to be introduced. Quantification of total maximum daily load from nonpoint source polluting ecosystem to ensure release of pollutants at permissible limits needed.
- Development of decision support system (DSS) using different models is required to disseminate the technologies suitable for saline irrigated environment to produce more yields per drop of water.
- Solute transport directly influences crop production as well as the surface and groundwater quality. Improving and optimising input delivery mechanism through overall input efficiency technology, irrigation methods recognition, integrated pest management, integrated nutrient management, improving the nutrient response ratio will minimise the risks associated with water quality.
- During the last 50 years, CGWB has been continuously monitoring the water level and water quality through 25000 stations for the entire country. There are 1600 stations governed by State agencies in Odisha. Convergence of databases on water quality of Central and State agencies at one platform will facilitate the stakeholders' interest for betterment of the society.
- The risk of contamination of unconfined aquifer by the pollutants present near the surface is more than the confined aquifer. Restoring aquifer is a difficult task and requires considerable time and effort. Therefore, implementation of preventive measures, technologies to safeguard the aquifer from pollution is the need of the hour.
- Proper tube-well construction technique need to be adopted in areas of multiple aquifer system to prevent intermixing of poor and good quality water for ensuring water quality within permissible limits.

- Nutrient management for saline environment requires additional doses of N fertilizers to compensate the volatilization losses. Use of green manuring, salinity and sodicity tolerant crop varieties, conservation agriculture practices, amendments like gypsum, pyrite, and use of growth promoters would create a sustainable environment.
- Conjunctive use of freshwater resources and saline-sodic water in right proportion is recommended for irrigation use. Secondary reservoirs and micro-irrigation system are promoted for exploitation of the full potential of surface and canal water system for enhancing agricultural water use efficiency.
- Extraction of fresh groundwater in coastal areas may be restricted within the permissible limit to avoid seawater intrusion. Studies on groundwater skimming may be carried out to decide the threshold level.
- Development of Institutional support mechanism is important for participation, development and optimal utilisation of water quality. Demand for groundwater may be managed through pricing, based on water quality.
- Incentives for water saving and adoption of improved technologies for managing saline water for food production may encourage the stakeholders.
- Capacity building of women and children in water management about water scarcity, judicious use of poor quality groundwater and its side effects, food grain losses due to salinity sodicity is essential.
- River cleaning is a major challenge in India and there is a need to identify polluting sources and areas along river in real time basis. Use of remote sensing images viz., Modis and Landsat, the extent of pollution in the river water can be assessed in real time basis.
- Regulations for development of ETPs to prevent industrial pollution and zero discharge needs to be framed by State Pollution Control Board (SPCB). Online real time monitoring telemetric network system needs to be installed at the outlet of industries to monitor the water quality.
- SPCB may frame regulations for development of Sewage Treatment Plants (STPs) to treat the municipal wastewater and communicate to the administration through municipal corporations.
- Tapping the drains to the STPS, household sewage connection has to be done through an integrated sewage management network. In relation to pollution from agriculture sources, there is pollution from non-point sources of nitrates, phosphates, pesticides residues, which need to be estimated.

Technological options to mitigate risk associated with water quality issues

- Inadequate attention to food-chain issue needs to be rectified through integrated approach as it provides yet another potential pathway of transmission of metal from water to food, thereby jeopardizing food biosafety.
- Studies in India indicate that groundwater in a large proportion of the Ganga, Meghna, Brahmaputra plains has significant levels of arsenic contamination placing up to 500 million people at risk.
- WHO (1993) recommends a maximum arsenic level of 10 µg/L in drinking water and Provisional Maximum Tolerable Daily Intake (PMTDI) of inorganic Arsenic at 2.1 µg/kg of body weight/day may be considered.
- Identification of suitable soil ameliorating substances like use of FYM and other manures besides green manure crops, inclusion of pulses/other legumes as well as application of appropriate amendments viz. Zinc / Iron /Silicon salts as and where applicable will reduce entry of arsenic into the plant.
- Efficient agro-techniques may be adopted for conjunctive use of surface and ground water during dry season as well remunerative cropping sequence with permissible groundwater quality for irrigation in the endemic area may be recommended.
- Intermittent ponding till 42 days after transplanting, followed by continuous submergence can reduce the usage of contaminated irrigation water without compromising grain yield of boro rice, as compared to continuous ponding.
- Identification or development of crop cultivars which accumulate less arsenic in the consumable parts and where ratio of inorganic to organic forms of arsenic is low. Development of cost-effective phyto (i.e. choice of especially rhizo-exclusive crops) and bio-remediation techniques.
- Creation of general awareness through mass campaigning, holding of farmers' day and pilot field demonstrations.
- It was revealed that there is no dearth of technology in treating wastewater as such but technology that requires less land, cost effective, user friendly and efficient resources recovery need to be prioritized.
- A small scale online hybrid filter developed by ICAR-Indian Institute of Water Management (IIWM) for in-situ treatment of wastewater that reduces sediment, heavy metal and microbial load need to be popularized.

- Microbial bioremediation is one of the promising techniques to treat wastewater. However, immobilization of the free cells to overcome the vulnerabilities of delicate free cells towards unfavourable conditions is crucial and need to be investigated.
- Multi-barrier approach like soil amelioration using lime to reduce the cadmium uptake in plant, selection of right crop like non edible crops, edible crops other than leafy, root vegetables and salad types which are eaten in raw form may be practiced when urban wastewater is used for irrigation in the peri-urban areas.
- It was recommended to adopt appropriate irrigation methods like drip and sprinkler over surface irrigation for wastewater. Sprinkler has certain limitations as wastewater encounters with parts of the plants. Drip irrigation was adjudged to be the best method of irrigation with wastewater.
- There should be 'Polluters' Pay Principle' to render the offenders taking responsibility of polluting water and creating menace to the society.
- There are mostly individual household-based treatment systems or cluster-based treatment systems in peri-urban and rural areas. BOD is the only parameter which is being monitored along with total soluble salt (TSS) but metals, pesticides, herbicides, etc need to be considered.
- The Water Technology Centre, ICAR-Indian Agricultural Research Institute has developed an Improved Decentralized Wastewater Treatment Technology named JalopcharTM based on Plant-Microbe-Media-mediated treatment system. The system reduces turbidity, pathogen, BOD, metals, nitrates and phosphates. The system requires low capital and less land than the conventional system, and needs to be implemented at several locations pan India.
- Organic and inorganic amendments were used to reduce the toxicity in soil and plant uptake of heavy metals. Cadmium (Cd) contamination can be remediated by using $CaCO_3$ as it converts Cd to less toxic octavite, $CdCO_3$.
- Crop variety like 'Badsabhog' translocates less amount of As from soil to grains. So, it can be used as donor parents for developing crop variety which can be cultivated to mitigate the heavy metal pollution in soil and plant. It was also recommended to adopt alternate wetting-drying planting method in rice, which could reduce As content in rice grains.
- It was recommended to use advance analytical tools or techniques to monitor newer emerging pollutants such as pharmaceuticals, organic pollutants, nanomaterials, personal care products and endocrine disruptors in water. The CSIR-Institute of Minerals and Material Technology (IMMT) developed and applied porous organic polymer for sensing and removal of mercury contaminants from

wastewater. The detection limit is as low as 45 ppb. Moreover, these polymers can be used repeatedly. They can also be used for aqueous phase ultra-fast removal of industrial dye and antibiotics from wastewater.

- Agricultural pollutions mainly nitrate in agricultural catchment areas is rampant and pollute groundwater as well as surface water. A robust monitoring system is needed to estimate loadings of nutrients in agriculture.
- It is imperative to identify the cause of nitrate (NO_3^-) pollution in groundwater. Where water table is shallow, low nitrate concentration was detected in ground water and a location where water table is deeper, high NO_3^- concentration was detected.
- There is a need to integrate information on water quality in the Irrigation Watershed Management Plan (IWMP) so that the water pollution aspect can be taken care of.
- Aquaculture management largely depends on water quality. There are many gaps in recommending the standards of water quality for different types of fish as well as different growth stages of fish. ICAR-Central Inland Freshwater Aquaculture has identified certain desirable parameters for aquaculture mainly for major carps but the biological parameters need to be investigated.
- Standard water quality parameters may be suggested for fish like pabda, magur, singi and many others, whereas such parameters are available for Rohu, Mrigal and Catla.
- It has been observed that in the hatchery pond due to the presence of higher amount of Ca and Mg, alkalinity and hardness is developed and that increases the mortality rate of fish pawns. To overcome this problem, farmers are advised to use rainwater for hatchery purpose.
- Gypsum and alum are recommended for reducing turbidity of water. Application of salt in fresh water or use of formalin to reduce ammonia is not advisable as it turns fresh water to saline water and formalin is carcinogenic in nature. Scope of biological filters to reduce ammonia is also narrowed because of its high cost.
- Nitrite concentration can be managed through oxidation or aeration and fish can tolerate about 20 ppm nitrate. Hydrogen sulphide derived from the protein feed of the fish was found high in water mostly in mangrove areas. Liming and water exchange was found useful in dealing with such problem.
- Ponds with low alkalinity and low hardness can be treated with lime. After harvesting of fish, disposal of pond water to fresh water system for irrigation use is not advisable as it leads to pollution because of presence of organic matter, fish feed and other contaminants.

Water quality issues and policy guidelines in Agriculture and Aquaculture

- Safe and readily available water is important for public health, whether it is used for drinking, food production, domestic use or recreational purposes. Improved water supply and sanitation besides its judicious management can boost Countries' economic growth and can contribute greatly to poverty alleviation.
- In 2010, the UN General Assembly explicitly recognized the human right to water and sanitation. Everyone has the right to sufficient continuous, safe, acceptable, physically accessible and affordable water for personal and domestic use.
- Contaminated water and poor sanitation are linked to transmission of diseases such as cholera, diarrhea, dysentery, hepatitis A, typhoid and polio. Inappropriately managed water and sanitation services expose individuals to preventable health risks.
- In 2020, 5.8 billion people used improved water resources free from contamination but 368 million people are still using water from unprotected wells and springs while 122 million people collecting untreated surface water from lakes, ponds, rivers and streams.
- Studies carried out by National Institute of Occupational Health (NIOH) assessed the hazards of metals in human body like neurotoxic, nephrotoxic, immune dysregulation, metabolic dysregulation, endrocrine disruption, cardiovascular problems, etc.
- The pesticide contamination in groundwater in Kasargod, Kerala due to spraying of endosulfan in cashew plantation disrupted the normal health of the people residing nearby and using the water. The abnormality in humankind is persisting in the village till date, which need to be prevented by judicious use or finding an eco-friendly measure.
- Models like Spatial Analysis and Decision Assistance (SADA) using modern tools viz., spatial data may be used to assess the risk of environmental pollution on human health.
- Full-Growth Huang Model, Re-paramaterized Gompertz Survival model may be used to assess the microbial risk assessment to express the disease burden. Studies are required to gather knowledge about the processes and mechanisms involved in human.

- The Disability Adjusted Life Year Loss (DALY) for India is 1700 DALY/million population, which is presently double the world average. It is calculated based on both morbidity and mortality, with the situation being very alarming, needs an immediate attention.
- Approach to control the non-point source pollution viz. regulatory approach to prohibit the discharge of pollutants; to limit the marketing of the dangerous product and manufacturing of that product like pesticides, herbicides etc., and to put restriction on agricultural practices in the location where the contamination of water is very high need to be adopted.
- Imposition of economic instruments like taxes on the pesticide use, herbicide use will enable farmers to apply these in optimum quantity. Besides lowering of subsidy on other inputs causing pollution will minimise the environmental pollution.
- Conversion of agriculture land to natural farming, organic farming and pasture and fallow lands and compensating the farmers by paying for loss of economic return also reduces contamination in surface and ground water.
- There are huge gaps in water quality management in India. The National Water Policy mostly focused on the quantity of the resource whereas the quality of water is a major threat to environment, ecology and human health.
- The public health care aspect is more focused while agriculture, silviculture, aquatic lives and livestock remain neglected. With the increased water scarcity, poor quality water is being used in agriculture without any guidelines and regulations, thereby posing threat to agriculture, mainly crops, livestock, aquaculture and groundwater which in turn affect the human health adversely.
- There are no simple or easily affordable policy choices regarding the use of untreated wastewater in developing countries, particularly where the institutional support for wastewater collection, treatment, and reuse is not yet well developed.
- Absence of synergies amongst Institutions (Central - State - Local Governments) as well as lack of participation of private Institutions in prioritizing the Water Quality Management Plan needs to be addressed.
- Absence of monitoring data and standards of heavy metals, pesticides, organics, etc. with respect to irrigation water creates uncertainties in managing water quality.
- Surface run-off from rural settlements is not linked to drainage system. Groundwater and surface water interaction in water quality management has not been studied in polluted areas.
- Lack of monitoring and penalty for open defecation, dumping of carcasses, disposal of dead bodies and desilting deteriorate water quality.

- Prioritizing waste treatment and waste storage facilities, waste utilization may improve the quality of surface and groundwater resources.
- The interaction of water and agriculture or aquaculture is complex. A systematic study on water quality issues in agriculture and aquaculture is the need of the hour for assessing and managing the risk in a constructive way with convergence of all the stakeholders and agencies associated with water quality.
- The water quality issues mainly in surface water and groundwater may be assessed from physical, chemical and biological perspective and then the risk may be managed in agriculture as well as in aquaculture using available technologies.
- Collection of Data from CWC, CGWB, CPCB, SPCB, BIS, demarcating and grading the polluted area applying modern tools like satellite data, data science, AI/ml by ICAR, SAUs, IIT and IISc, upscaling of suitable technologies available by ICAR, CSIR, IIT, IISc and other research organizations, monitoring water quality using modern tools by CWC, CGWB, CPCB, SPCB,IIT, CSIR, ICAR and assessing target hazard to soil crop, fish and human by apex Institutions need to be prioritized.

Salient Recommendations

1. Convergence of Institutions (Central - State - Local Governments) with participation of private Institutions and stakeholders either in a collaborative way or Public-Private Partnership (PPP) mode or participatory approach may address the water quality issues in agriculture and aquaculture with an integrated framework.

2. Construction of dedicated online portal at the national level with single point access to the real time data related to water quality and its related aspects. Setting up of more numbers of Water Quality monitoring stations besides using modern tools like satellite data, IoTs, chemosensors, bio-probes to monitor water quality with higher frequency.

3. Development of water quality maps and delineation with classification of polluted area applying modern tools and validation through ground truthing. Development of Decision Support System using different models for technology dissemination and safe use of poor quality water in agriculture and aquaculture.

4. Segregation based on grades of water quality and decentralization of differential wastewater treatment systems using low-cost, user-friendly and landless technologies. Prioritizing and upscaling of the suitable technologies to mitigate water quality issues. Adoption of multi-barrier approach in wastewater irrigated agriculture and aquaculture comprising crop selection, judicious irrigation methods and scheduling, soil amendments and filtration techniques.

5. Comprehensive research at the national level as well as regional level using bigdata analytics, AI/ml to understand the mechanism of contamination viz., salinity, nitrate, heavy metals, biological loads, organics and microplastics in water-soil-plant/fish-human continuum.

6. Developing stringent framework with SOPs and guidelines comprising ICAR, ICMR and Water resource departments, CPCB and BIS to prescribe permissible limit of heavy metals, pesticides, pharmaceuticals and other hazardous parameters in water, food-chain from field to fork is necessary.

7. Use of groundwater laden with geogenic contaminants (such as arsenic, selenium, fluoride) for irrigation and the associated health hazards from the entry of these toxins in the human food-chain needs to be given a special consideration; the necessary remedial measures for arresting and/or minimizing the associated health hazards need to be worked out. Quite an extensive amount of laboratory and field data already is available in literature.

8. Anthropogenic activities, discharge of wastewater (municipal and industrial) to canals, lakes, wetlands or rivers that accumulate nutrients, organics resulting in eutrophication may be regulated. Concept of quantification of total maximum daily load may be imposed. Eco friendly industrial and agricultural production system through waste management and zero discharge should be prioritized.

9. Protocol for fixing responsibility and liability of maintenance at corporate level and also at individual level for polluting the fresh water. Enforcement of polluters pay principle for point source pollution. Imposing economic instruments like taxes on harmful inputs and minimizing subsidies and promoting natural farming, organic farming, INM, IPM, recycling of farm wastes may reduce the contamination in water.

10. Farmers and other stakeholders need to be encouraged by providing cash incentives for using treated wastewater for irrigation based on ecosystem services.

11. Awareness and capacity building of the growers and consumers about the risk associated with water quality and its management.

12. Inclusion of policy guidelines on water quality for agriculture and aquaculture in National Water Policy Document and ensure its implementation to maintain water quality at National level.

ICAR-Indian Institute of Water Management, Bhubaneswar, Odisha

Brainstorming Workshop on Water Quality Issues and Policy Guidelines in Agriculture and Aquaculture

13th January 2023

Convener : Dr. Arjamadutta Sarangi, Director, ICAR-IIWM, Bhubaneswar, Odisha

Organizing Secretary : Dr. Mausumi Raychaudhuri, Principal Scientist, & Dr.Dibakar Ghosh, Scientist

Inaugural session:

Sl No.	Time	Item
1	09:30-09:40 hrs	Welcome address by Dr.Arjamadutta Sarangi, Director, ICAR-IIWM, Bhubaneswar, Odisha
2	09:40-09:43 hrs	Brief about the programme by Dr. Mausumi Raychaudhuri, PS, ICAR-IIWM
3	09:43-09:58 hrs	Inaugural address by Dr. S.K. Chaudhari, DDG (NRM), ICAR New Delhi
4	09:58-10:00 hrs	Vote of thanks by Dr. Mausumi Raychaudhuri, PS, ICAR-IIWM

Tentative Technical Schedule

Sl No.	Time	Topic	Resource Person	Affiliation
Co-convener: Dr. S.K. Jena, PS & Programme Leader, ICAR-IIWM Session-I Water quality issues and risk assessment Chairman – Dr. R.C. Srivastava, Former Vice-Chancellor, DrRPCAU, Pusa, Bihar Co-Chairman – Er S.K. Samal, Director, CWC, Bhubaneswar Rapporteur – Dr.Roomesh Jena, Scientist, ICAR-IIWM, Bhubaneswar				
1.	10:00-10:15 hrs	Water quality issues in India and way forward	Dr. R.C. Srivastava	Former Vice-Chancellor, Dr RPCAU, Pusa, Bihar
2.	10:15-10:25 hrs	Water quality issues in Aquaculture (Fresh water)	Dr.Subir Nag	Head, ICAR-CIFRI, Kolkata

3.	10:25-10:35 hrs	Water quality issues in Aquaculture (Saline water)	Dr. Vinod Kavungal	Scientist I/c, Calicut Regional Centre, ICAR-CMFRI
4.	10:35-10:45 hrs	Water quality scenario of Brahmani& Subarnarekha Basin	Er S.K. Samal	Director, CWC, Bhubaneswar
5.	10:45 -10:55 hrs	Design of molecular probes for detection of contaminants in water	Dr. B. P. Bagh	Sr. Principal Scientist CSIR-IMMT, Bhubaneswar
6.	10:55-11:05 hrs	Issues and guidelines of using poor quality water in agriculture	Dr.Khajanchi Lal	Principal Scientist ICAR-IARI, WTC New Delhi
7.	11:05-11:15 hrs	Present status of water pollution in India	Mr. M.K. Biswas	Regional Director & Scientist E CPCB, Kolkata
8.	11:15-11:30 hrs	Interaction		

Co-convener: Dr. S.K. Rautaray, PS & Programme Leader, ICAR-IIWM
Session-II Impact of poor quality water on natural resources
Chairman : Dr.Arjamadutta Sarangi, Director, ICAR-IIWM
Co-Chairman: Dr. B. K. Sahoo, Scientist E, CGWB, SE Region, Bhubaneswar, M/o Jal Shakti
Rapporteur: Dr. P.P. Adhikary, Senior Scientist, ICAR-IIWM

1.	11:30-11:45 hrs	Spatio-temporal variability of water quality parameters	Dr.Arjamadutta Sarangi	Director, ICAR-IIWM, Bhubaneswar
2.	11:45-11:55 hrs	Movement of solute/ nutrients/contaminants from to different water resources	Prof. B. S. Das	Professor, Agricultural and Food Engineering, IIT Kharagpur
3.	11:55-12:05 hrs	Monitoring of Groundwater quality and database sharing	Dr. B. K. Sahoo	Scientist E, CGWB, SE Region, Bhubaneswar, M/o Jal Shakti
4.	12:05-12:15 hrs	Using modern tools to assess water pollution	Dr. Bhabagrahi Sahoo	Associate Professor School of Water Resources, IIT, Kharagpur

5.	12:15-12:25 hrs	Risk associated with wastewater irrigation in soil	Dr.JayantaSaha	Principal Scientist ICAR-IISS, Bhopal
6.	12:25-12:35 hrs	Managing saline water for irrigation	Dr. M. J. Kaledonkar	Principal Scientist & PC, Saline water ICAR- CSSRI, Karnal
7.	12:35-12:45 hrs	Present status of water pollution in Odisha with respect to agriculture and aquaculture	Mrs. Usharani Patnaik	Senior Environmental Scientist, SPCB, Bhubaneswar
8.	12:45-13:00 hrs	Interaction		
Lunch 13:00-14:00 hrs				

Co-convener: Dr. Mausumi Raychaudhuri, PS & Programme Leader, ICAR-IIWM
Session-III Technological options to mitigate risk associated with water quality issues
Chairman: Dr. S. K. Sanyal, Former, Vice Chancellor, BCKV, Mohanpur
Co-Chairman: Professor SekharMuddu, IIS, Bangalore
Rapporteur: Dr.AsishMaity, Senior Scientist, ICAR-IIWM

1.	14:00-14:15 hrs	Arsenic in Human Food-Web and Mitigation Options	Prof. S.K. Sanyal	Former Vice-Chancellor, BCKV, Mohanpur, West Bengal
2.	141:5-14:25 hrs	Treatment options for urban wastewater for its safe use in irrigation	Dr. S. Raychaudhuri	Principal Scientist ICAR-IIWM, Bhubaneswar
	14:25-14:35 hrs		Dr. R. Kaur	Principal Scientist, ICAR-IARI, WTC New Delhi
3.	14:35-14:45 hrs	Porous organic polymer removing organic and inorganic micropollutants	Dr.Sanjib Das	Principal Scientist CSIR-IMMT, Bhubaneswaar

4.	14:45-14:55 hrs	Metal and metalloid pollution in soil and water	Dr. S.P. Datta	Professor Division of Soil Science and Agricultural Chemistry ICAR-IARI, New Delhi
5.	14:55-15:05 hrs	Smart solutions to maintain water quality using IoT tools	Prof. Sekhar Muddu	Dept. of Civil Engg. Indian Institute of Science, Bangalore
6.	15:05-15:15 hrs	Managing water quality for aquaculture	Dr. Subhendu Adhikary	Principal Scientist & SIC, RRC, ICAR-CIFA, Rahara, Kolkata
7.	15:15-15:30 hrs	Interaction		
Co-convener: Dr. R.K. Panda, PS & Programme Leader, ICAR-IIWM Session-IV Policy guidelines for safe water use in Agriculture and Aquaculture Chairman: Dr.PratapBirthal, Director, ICAR-NIAP, New Delhi Co-Chairman: Mr. JagannathMajhi, Senior Director and Scientist F, BIS, Bhubaneswar Rapporteur: Dr.AnkhilaHandral, Scientist, ICAR-IIWM				
1.	15:30-15:40 hrs	Water quality standards: Present and Future	Mr. Anurag	Asst. Director, BIS, Bhubaneswar
2.	15:40-15:50 hrs	Water quality and health issues	Dr. P. K. Nag	Former Director ICMR-NIOH, Ahmedabad
3.	15:50-16:00 hrs	Present scenario of municipal waste water at Bhubaneswar	Vijay AmrutaKulange	Commissioner, BMC, Odisha
4.	16:00-16:10 hrs	Suggestive measures to reduce the negative impact of poor quality water on human health	Dr. Sanghamitra Pati	Director, ICMR-RMRC, Bhubaneswar

5.	16:10-16:15 hrs	Agriculture with wastewater	Mr. Rabindra Kumar Khatua	Joint Director of Agriculture & Food Production, DAFE, Govt of Odisha
6.	16:15-16:25 hrs	Policy Guidelines to maintain water quality	Dr. Mausumi Raychaudhuri	Principal Scientist ICAR-IIWM, Bhubaneswar
	16:25-16:35 hrs	Interaction		
7	16:35-17:00 hrs	Recommendation and closing ceremony		

List of Panelist

1.	Dr. Suresh Kumar Chaudhari	Deputy Director General (Natural Resource Management) Division of Natural Resource Management, Krishi Anusandhan Bhawan-II, New Delhi - 110 012
2.	Prof. Saroj Kumar Sanyal	Former Vice-Chancellor, BCKV, Mohanpur, West Bengal
3.	Dr. R. C. Srivastava	Former Vice-Chancellor, DrRPCAU, Pusa, Bihar
4.	Er. S. K. Samal	Director, CWC, Bhubaneswar
5.	Dr. Arjamadutta Sarangi	Director, ICAR-IIWM, Bhubaneswar
6.	Mr. M. K. Biswas	Regional Director & Scientist E CPCB, Kolkata

7.	Dr. Pratap Birthal,	Director, ICAR-NIAP, New Delhi
8.	Dr. P. K. Nag	Former Director ICMR-NIOH, Ahmedabad
9.	Dr. Subir Nag	Head, ICAR-CIFRI, Kolkata
10.	Prof. Sekhar Muddu	Professor, Dept. of Civil Engg. Indian Institute of Science, Bangalore
11.	Prof. B. S. Das	Professor, Agricultural and Food Engineering, IIT Kharagpur
12.	Dr. B. K. Sahoo	Scientist E, CGWB, SE Region, Bhubaneswar, M/o Jal Shakti, GOI
13.	Dr. Vinod Kavungal	Scientist I/c, Calicut Regional Centre, ICAR-CMFRI
14.	Dr. B. P. Bagh	Sr. Principal Scientist CSIR-IMMT, Bhubaneswar
15.	Dr. Bhabagrahi Sahoo	Associate Professor, School of Water Resources, IIT, Kharagpur

16.	Dr. Sidhartha Giri	Scientist E ICMR-RMRC, Bhubaneswar
17.	Dr. M. J. Kaledonkar	Principal Scientist &PC, Saline water ICAR- CSSRI, Karnal
18.	Mrs. Usharani Patnaik	Senior Environmental Scientist, SPCB, Bhubaneswar
19.	Dr. S. Raychaudhuri	Principal Scientist ICAR-IIWM, Bhubaneswar
20.	Dr. R. Kaur	Principal Scientist, ICAR-IARI, WTC New Delhi
21.	Dr. Sanjib Das	Principal Scientist CSIR-IMMT, Bhubaneswaar
22.	Dr. S. P. Datta	Professor Division of Soil Science and Agricultural Chemistry ICAR-IARI, New Delhi
23.	Dr. Subhendu Adhikary	Principal Scientist & SIC, RRC, ICAR-CIFA, Rahara, Kolkata
24.	Mr. Rabindra Kumar Khatua	Joint Director of Agriculture & Food Production, DAFE, Govt of Odisha
25.	Dr. Mausumi Raychaudhuri	Principal Scientist ICAR-IIWM, Bhubaneswar

List of Participants from ICAR-Indian Institute of Water Management

Sl. No.	Name	Designation
1	Dr. R. K. Panda	Principal Scientist
2	Dr. Prabhakar Nanda	Principal Scientist
3	Dr. S. K. Rautaray	Principal Scientist
4	Dr. S. K. Jena	Principal Scientist
5	Dr. R. K. Mohanty	Principal Scientist
6	Dr. Sheelabhadra Mohanty	Principal Scientist
7	Dr. A. K. Thakur	Principal Scientist
8	Dr. P. K. Panda	Principal Scientist
9	Dr. H. K. Dash	Principal Scientist
10	Dr. Ranu Rani Sethi	Principal Scientist
11	Dr. D. K. Panda	Principal Scientist
12	Dr. B. K. Sethy	Principal Scientist
13	Dr. A. K. Nayak	Principal Scientist
14	Dr. P. Panigrahi	Principal Scientist
15	Dr. S. K. Mishra	Principal Scientist
16	Dr. D. C. Sahoo	Principal Scientist
17	Dr. P. P. Adhikary	Senior Scientist
18	Dr. Sanatan Pradhan	Senior Scientist
19	Dr. O. P. Verma	Senior Scientist
20	Dr. A. Y. Maity	Senior Scientist
21	Dr. B. S. Satapathy	Senior Scientist
22	Dr. Debabrata Sethi	Scientist
23	Dr. Prativa Sahu	Scientist
24	Er. Ajit Kr. Nayak	Scientist
25	Mr. Biswaranjan Behera	Scientist
26	Dr. Ankhila R. Handral	Scientist
27	Dr. Roomesh Kr. Jena	Scientist
28	Dr. Dibakar Ghosh	Scientist
29	Dr. Ankita Jha	Scientist

Abbreviations

Units

Mha	Million hectare
mm	millimeter
BCM	Billion Cubic Meter
MCum	Million cubic meter
µg/L	Microgram per Litre
µg/kg	Microgram per kilogram
mg/kg	Milligram per kilogram
ppm	parts per million
ppb	Parts per billion
ppt	parts per trillion

Water quality Parameters

WQ	Water Quality
EC	Electrical Conductivity
BOD	Biological Oxygen Demand
COD	Chemical Oxygen Demand
TSS	Total Suspended Solid
TDS	Total Dissolved Solids
Cl-	Chloride
NO2-	Nitrite
NO3-	Nitrate
PO4-3	Phosphate

SO4-2	Sulphate
F-	Fluoride
NH4+	Ammonium
Na+	Sodium
K+	Potassium
Ca+2	Calcium
Mg+2	Magnesium
As	Arsenic
Cd	Cadmium
Cr	Chromium
Cu	Copper
Fe	Iron
Pb	Lead
Ni	Nickel
Co	Cobalt
Mn	Manganese
Zn	Zinc
Se	Selenium
Sb	Antimony
V	Vanadium
CaCO3	Calcium carbonate
CdCO3	Cadmium carbonate
PCP	Phenylcyclohexyl piperidine
SOPs	Standard Operating Procedures

Institutions

CWC	Central Water Commission
BIS	Bureau of Indian Standards
WQ	Water Quality
CGWB	Central Ground Water Board
CPCB	Central Pollution Control Board
SPCB	State Pollution Control Board
BIS	Bureau of Indian Standards
ICAR	Indian Council of Agricultural Research
SAUs	State Agricultural Universities
IIT	Indian Institute of Technology
IISc	Indian Institute of Science
CSIR	Council of Scientific & Industrial Research