IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

Pathways for Climate Resilient Water Security At Bengaluru Urban,India

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ABSTRACT

This paper is based on a research work on climate resilient water security for Bengaluru urban. UNIPCC 2021 10 pathways, national legal and state action plans for climate resilience are listed and used for a critique on Urban wastewater management. An Indigenous WATCHIT software for Water Quality Monitoring has been deployed for 34 urban stations water quality assessment. Water balance for Bengaluru urban has been reviewed based on UN best practices formats. Validation by Environmentally Sound Technology and Ecological Engineering Principles are found relevant. Space enabled by geospatial temporal data and community participation are found climate resilient . A vision, agenda and a time bound action plan for climate resilient water security at BWSSB is found necessary. Enabling community to care for its water security mandates six specific actions and are suggested.

Key Words : IETC, Climate Adaptation, UNIPCC, WMO,WHO, Community Enabling.

1.0 Introduction

Climate change induced recurring urban deluge and drought cause economical and ecological losses. Globally, over 207 urban settlements have embarked on climate resilient adaptation (Satterthwaite, 2018). Policy gaps are also found constraints in climate adaptation (Rockstorm,2021).Simple scientific pathways need low energy intensive technologies in harnessing water and waste water. Technologically, the options need to be based on Environmentally Sound Technology(UNIETC, 1992). Technologies range from closed loop life supports at zero gravity converting human urine and faeces to simple gas and water. This has been operation at International Space Station (Kupiers, 2021). On ground, nature and community-based solutions are found climate resilient practical cases (WMO, 2021).

Cauvery river is the main source of drinking water for urban Bengaluru. Totally 1450 MLD of Cauvery water is collected, treated and conveyed by pumping in three stages. Potable water is charged Rs 7/KL for the first slab up to 8000 liters. Rs 70-80 Crores/month is the electrical bill and Rs 30 Crores for Operation and Maintenance of Water Supply and Sewerage Systems, Contrary to what most people think, Bengaluru urban receives 5 times as much rainwater from outside sources. Regarding strategies on sustainable Bengaluru urban water management efforts are made(Jan and Chandra, 2017; Jagannatha , 2007).

The "reliability" and "longevity" of DEWAT systems facilitate the permanent and ongoing treatment of wastewater flows ranging from 1-1000m3 per day, from both domestic and industrial sources (Ulrich et al., 2009). Due to their adaptability, effectiveness, and affordability, these systems are created to support centralized wastewater treatment technologies and initiatives that seek to lower overall wastewater generation.

Bangalore metropolis has 24 larger-sized sewage plants, the largest being 248 MLD at K&C Valley, for the treatment of waste water for climate resilience. Moreover, integrated SCADA (Supervisory Control and Data Acquisition) systems are in use (BDA, 2017; BWSSB, 2017 and BDDMP, 2022).

As per a vision Lakes are the eyes of the Earth. Bengaluru Lake heritage is at (Report, 2018). More than 150 surface water bodies in the Bruhat Bengaluru Mahanagara Palike (BBMP) are on a restoration strategy. Spatial-temporal data are known to enhance urban government (Ganeshraj, et.,al., 2018), (Jagannatha,1995; 2018)

Thirty-six percent of the water quality issues in each of Bengaluru's four metropolitan districts are caused by inadequate recharge and pollution. Over exploitation in the remaining 56% is brought on by a complete reliance on groundwater and hasty bore well drilling.

It is established that spatial temporal data could strengthen urban environmental governance (Prabhuraj et al., 2013). On the Water supply and quality in each of Bengaluru's four urban districts from insufficient recharge, pollution causes 36% of the district's water quality problems. In the remaining 56%, over-exploitation is caused by a total reliance on groundwater and careless bore well drilling. As early as 1980s, growth of Bengaluru based on survey maps and satellite imageries revealed the trend of building up water insecurity (Beherra et al., 1985). An active ground water program is also worked out all over the state of Karnataka (CGWB, 2013). Namma Metro has also many useful data on the hydro geological issues relevant to water Security ground water security at Bengaluru Urban (BMRCL2A ,2019).

Traditional and cutting-edge IT with space data systems are working for Emergency and Disaster Management. Simple indigenous IT tools such as WATCHIT are found reliable and essential (Govindaraju, et al., 2022). For the Bengaluru region's water security in the face of a changing climate, key best practices include the development of over 1.4 Million trees (ENVIS -TR-75 2014) and the use of trees as recharge possibilities (Jagannatha 2017; 2022). These and other factors are found relevant for inter relatedness and Interdependence for the research work. The management strategies are also available for Bengaluru Developmental domains (BUIR, 2023; Raj.,et al., 2022).

The ongoing use of satellite technology and space datasets with verified ground data provides the global context and serves as the foundation for UN IPCC research and report. The theory and supporting evidence are combined to produce actionable inputs. A bird's eye view of the steps involved in climate action is provided in Fig. 1.1. The key relationships, patterns, and strategies for lowering risks and building resilience are discussed.

Fig.1.1. Main interactions and trends and options to reduce risks and establish resilience (IPCC, 2022)

In the graphic, relationships between ecosystems (including biodiversity) and interactions between humans and their effects on the environment are depicted in blue (red). The arrows in Fig. 1.1 above show ecological interactions (green), biodiversity-related interactions, as well as the decreased effects of climate change and human activity (IPCC, 2022).

By 2030, the world's buildings must not only become significantly more energy efficient, but also switch to zero-carbon energy. Climate resilience for the civil engineering area, Decarbonizing Buildings is a focus for GHG. For instance, development has halted recently after declining in the 2000s and the early 2010s in terms of the amount of energy used per square metre of floor space in buildings (also known as energy intensity). In order to limit warming to 1.5 degrees Celsius over the course of this decade, residential and commercial buildings will need to improve their energy efficiency approximately seven times faster and five times faster, respectively.

Next to issues of quality and quantity of available water for any functional use, ever galloping disasters matter.

EM DAT has been weekly reporting on the disasters since 1988. For the week of February 13–February 19, 2023, Table 1. offers a typical weekly monitoring, with a year and a number provided by each stakeholder for action (EM-DAT 2023).

TABLE 1. : EM-DAT: DISASTERS OF THE WEEK

Week 8-2023: February 20 - February 26

Natural disasters:

2023-0091	Earthquake (2); Turkey and Syrian (Arab Rep)
2023-0092	**Floods and landslides**; (Sao Paulo state), Brazil
2023-0095	Tropical cyclone 'Freddy'; Mauritius, Madagascar & Mozambique
2023-0096	**Floods** ; West Java, Indonesia
2023-0099	**Floods and landslides**; Ecuador
2023-0100	Severe weather; Morocco

2023-0101 **Floods and landslides;** Central Java and Sulawesi, Indonesia
2023-0108 **Floods**; Zamboanga Peninsula Region, Philippines
2023-0110 **Floods**; Southern province, Zambia
2023-0111 Cold wave; Lebanon
2023-0114 Severe weather; California and Oregon, USA

Technological disasters:

2023-0081 Road accident; Limpopo province, South Africa
2023-0084 Road accident with migrants; Gualaca, Panama
2023-0097 Coal mine collapse; Inner Mongolia, China
2023-0105 Shipwreck with migrants: near Crotone, Italy
2023-0106 Bus accident; near El Asnam, Algeria

It is clear from the foregoing that out of 11 natural disaster incidences during week 8, 6 of them involved flooding. These online accounts of technology and natural disasters offer a wealth of planning, action, and learning opportunities. Bangalore District Disaster Management is in charge of disaster management in Bengaluru (BDDMP, 2022). Compensation for losses in life and property is expressly mentioned on the front page. Throughout the country, KSNDMC is the only organization that uses cutting-edge software, hardware, and web-enabled applications at the Master Control Facility to monitor natural disasters. The Center has been offering scientific studies, early warning, and meso-scale weather forecasts at the Hobli level for managing natural disasters in Karnataka(KSNDMC, 2023),.

Regionally, climate change impacts studies reveal that, Asia alone has now 58 of the world's largest cities compared to 22 in 1900 (Satterthwaite, 2018). Climate change has worldwide consequences, yet it disproportionately affects the poor and vulnerable. The 47 Least Developed Countries (LDCs) are unnecessarily exposed to the negative repercussions of global warming. LDCs have accounted for 69 percent of global mortality due by climate-related disasters over the last 50 years. Droughts, floods, landslides, and storms killed almost 1,200 people in LDCs in the first half of 2019, affecting around 11 million more and with passing of time fatalities increase (CRED-EDMAT, 2019).

When floods occur, implications on urban infrastructure due to climate change for roads and building damage are severe. The businesses will be unable to operate as a result of sudden events such as flooding. Reduced rains raise the cost of food and other agricultural supplies. Normal production and distribution for a productive living are adversely affected**. Climate change may cause disruptions in drinking water and electricity generation. In many cases insurance firms may face greater claims and may not compensate the loss and damage fully.**

Responses based on field actions from over 207 global cities benefiting over 394 Million population vindicate the fact of concern and action. Climate change adaptation has also produced a more resilient environment for business to thrive. Climate change risks are being mitigated through infrastructure and service investments, as well as the development of regulations and incentives. Cities are predicted to create 80% of GDP, and the value of assets at danger from climate change by 2030 is estimated to be $ 4 trillion.

International collaboration has been demonstrated in the effort to combat climate change. a UNDP monthly report called **ClimatePromise.undp.org** updates the actions on this. Japan has pledged 42 million dollars to support 23 nations with national commitments in accordance with UNCC Cop 26, Nov. 21, and IPCC reports released in Feb 2022.. This home page focuses on the climate resilience compliance of 120 countries to reduce Green House Gas emissions. Net Zero Pathways, Adaptation and Resilience, Green Jobs and Just Transition, Inclusion, Climate Finance, Climate Economy, Covid-19 Recovery, and Energy are among the areas of attention (UNDP, 2022). There are many space technology in international collaborations dedicated to water problems(ESA, GoN, 2021).

On the focus of the topic, the Energy consumption for conventional water abstract and waste water management is identified as a significant source of GHG emissions. Energy efficiency measures, along the water and wastewater management cycle, can decrease energy consumption and related CO2 emissions. Experience from water utilities, which have started to measure, reduce, and report their GHG emissions, needs to be scaled up to Decarbonizing water and wastewater management.

Yet, a significant proportion of the wastewater generated in cities and rural areas remains untreated or only partially treated, with the emissions from untreated wastewater being an estimated three times higher than emissions from conventional wastewater treatment plants. The extension of wastewater collection and treatment systems, including decentralized solutions, emerges as a win-win for development and climate mitigation. Thus, actual Strengthening the assessment, monitoring, and reporting of GHG emissions from water and wastewater handling, including on-site sanitation, must be a priority for better GHG estimates and access to climate finance (Ingemarsson, et al., 2022).

Thus, it is evident that a realistic documentation of all water and waste water systems in urban settlements is vital to understand the cause and effect relationship in climate change. It is also scientifically evinced that data will be useful for carbon credit, carbon footprint and UNCC Cop negotiations by the respective nations for the present and future.

UNIPCC **(**2022) report reveal issues of serious concern for India. **India with 7,517 km of coastline, will face significant threats from rising seas. Across six Indian port cities - Chennai, Kochi, Kolkata, Mumbai, Surat and Vishakhapatnam - 28.6 million people will be exposed to coastal flooding for a sea levels rise of 50 cm as per one study. India is currently the world's fourth largest greenhouse gas emitter (if the EU is counted as one block), but per capita emissions are much lower. The US emitted nearly 9 times more greenhouse gases per capita than India in 2018.**

An increase in annual mean precipitation is projected In India. The increase in rainfall will be more severe over southern parts of India. On the southwest coast, rainfall could increase by around 20%, relative to 1850-1900. It is fore casted that, If it is warm by 4°C, India could see about a 40% increase in precipitation annually.

Monsoon precipitation is projected to increase in the mid- to long term over South Asia. Globally, severe, heavy precipitation events that now occur on average once every ten years, are projected to nearly double in frequency at 2°C (1.7 times in a ten-year period). At 4°C, the likelihood of these events will jump to 2.7 times in a ten-year period (Bhaduri, 2021).

Review of Karnataka State Action Plan on Climate Change :2013, KSAPCC 2013 focus on possible impacts on **water resources** among other sectors.The "Action Plan" comprises a comprehensive action plan spanning all the sectors identified. It defines more than 200 action points necessary to enhance Karnataka's preparedness for climate change (Mukurjee, et al., 2013).

Further, Karnataka State Action Plan on Climate Change : 2021, is based on a National Guideline. The Ministry of Environment, Forest & Climate Change (MoEF&CC) formulated and circulated a common framework for State Action Plan for Climate Change SAPCC in 2019, with 10 principles. These State Action Plan on Climate Change consider Institutional engagements and stakeholders participation and Capacity building for Climate adaptation(EMPRI, 2021). In India, after the Disaster Management Act 2005, each district has a district disaster Management Plan ((BDDMP, 2022),

One of the most relevant background for climate resilient water security for Bengaluru is Water Safety Plan (WSP) since 2014. **WSP aims to guarantee water supply with quality assurance from the source to the customer.** WSP has reportedly benefited many nations including India. Two cities, Nagpur and Hyderabad and two wards at Bangalore are benefited by the WSP program so far (EMPRI, 2019).

2.0 Materials and Methods

Case studies of water quality and water and wastewater treatment plants are considered for climate resilient review. They are considered under the following two heads 1. Water Quality assessment using Computer Simulations and 2, Case Studies of Waste water treatment plants.

2.1 Water Quality for Climate Resilience by Monitoring using WATCHIT.

Water Quality test results for the year 2020-21 were sourced from Karnataka State Pollution Control Board Laboratory, Bengaluru. 34 Urban stations ground water quality parameters were used in the WATCHIT computer software. Simulated test results were taken for Irrigation and Industrial Indexes and suitability of respective functional need of water quality ascertained (Table 2.1).

Table: 2.1 Water use and major parameters

Sl.No	Table No.	Water use	Major Parameters
1	3.1a	Physic-chemical parameters of water : Urban	TDS, EC, pH, and Temperature
2	3.1b	Industrial water quality parameters	Rhyzner's Index, Aggressive Index, Pollution Index, Pokoproius Index, Larson KD Index. Kelly SR Ratio
4	3.1c	Irrigation water quality parameters	Permeability Index, Salinity USSL, NA- Hazard Index

34 villages water quality data Urban Bengaluru were entered in to the WATCHIT. The results were down loaded and based on Indices, the water suitability was ascertained for irrigation and Industries]uses.

2.2 Case studies : Best Practices in waste water treatment :

Bengaluru region inherits climate resilience in water supply and sewerage systems since it was founded in 1537 AD. A total of 21 case studies were selected for a review. Cases were selected and analyzed for climate resilience. These cases were from Devanahalli FSTP 1 No) ISRO(2 Nos), BWSSB(3 Nos), SWR(3 Nos), HAL(4 Nos), NACIN(2Nos), METRO Rail(4 Nos), BIAL(1No), Atal Bhoojal Project(1 No) and a Eco Home grey water use (1 Nos).

The basis for selection was age of the treatment plant, scale of operation and technology deployed. These were further analyzed for climate resilience considering their ecological niches and 1) UN IPCC ten pathways, (Rockstorm, 2021) 2) UN IETC Environmentally Sound Technology (UN IETC, 1999), 3)Ecological Engineering aspects (IEES, 1996), 4) National Statutory Compliance and 5) KSAPCC 1 and 2,

Most of them were in the role of meeting over decades of statutory compliance but also effectively defraying demand on fresh water.

Primary data was collected and analyzed for working details of the initiative and evaluated for climate resilience water security. A standard UN format www.//www.un.org/esa/earthsummit/w-sumida.htm for best practices in WRM was used. The format had a simple format with a dozen details seeking fields. Following details were collected in a format sent 1) Title 2) Location 3) Responsible Organization 4) Description 5) Issues Addressed 6) Objectives 7) Results Achieved 8) Lessons learnt 9) Financing 10) Contact 11) Any other information details such as Outsource, if any and 12) Home page.

A formal letter of permission from KSPCB seeking data from the concerned authorities was enclosed with the UN format. The format had a case study for easy understanding to fill up the format. The two page format was used in filling the form during the field visits or collected by post or over e mail. Standard UN format in UN standards format for best practices in Water sector. A detailed analysis of the case studies and discussions are at Table : 3.2

3.0 Results and discussions

WATCHIT Water chemistry simulation for all the 34 Bengaluru urban stations provided the following results in the form of 272 Tables and 22 graphs. The details of the results and discussions of three tables are considered to validate the suitability of water for irrigation and industrial uses are listed below:

3.1 Important ground water quality parameters considered for 34 Bengaluru urban regions are shown in Table 3.1a

1. **TDS : Total Dissolved Solids:.** TDS comprises salts, Inorganic salts are made up of the positively charged cations (calcium, magnesium, potassium and sodium) and negatively charged anions (carbonates, nitrates, bicarbonates, chlorides and sulfates)

2.EC (mmhos/Cm): Electrical conductivity is a measure of the saltiness of the water, Freshwater is usually between 0 and 1,500 uS/cm and typical sea water has a conductivity value of about 50,000 uS/cm. Low levels of salts are found naturally in waterways and are important for plants and animals to grow.

3.pH: The pH of water is a measure of the acid–base equilibrium and, inmost natural waters, is controlled by the carbon dioxide–bicarbonate carbonate equilibrium system. An increased carbon dioxide concentration will therefore lower pH. Temperature will also affect the equilibrium and the pH. In pure water, a decrease in pH of about 0.45 occurs as the temperature is raised by 25 °C

4.T: Temperature influence on water chemistry. The rate of chemical reactions generally increases at higher temperature. Water, particularly groundwater, with higher temperatures can dissolve more minerals

3.2 Results of the Bengaluru Urban stations water quality for Industrial use were analyzed and clustered as per the rankings (Table 3.1b)

1 : RSI: 4.0 to 5.0 : the water is strongly encrusting,

5.0 to 6.0 : it is slightly encrusting,

6.0 to 7.0 : it is slightly encrusting or corrosive,

7.0 to 7.5 : it is significantly corrosive,

7.5 to 9.0 : it is strongly corrosive, if the value is

9.0 or higher, the water is unbearably corrosive.

Suitability of ground water for Industrial Use as per Rhyzner's Index.

Index:**4-5 RSI** : No Station:

5.0-6.0 RSI : Stations :2,4.11.20 :

6.0-7.0RSI:Stations1,3,5,7,10,12,14,15,16,17,

18,19,22,23,26,28,29,31,32 and 34.

Inference : Water quality indicate slightly encrusting or corrosive in 88% of the stations

Also, Results of the Bengaluru Urban stations water quality for Irrigation use were analyzed and clustered as per the rankings Suitability of ground water for domestic Use as per Water Pollution Index.

Index:

Water Pollution Index:

Up to 2 : Unpolluted,

2-6 : Slightly Polluted,

6-20 Moderately Polluted

> 20 Polluted

Of the 34 Bengaluru URBAN Sampling Stations WATCHIT Simulation trends show trends of

Up to 2 WPI : Unpolluted : Stations 6,11,

2 to 6 WPI : All other than 31 stations Slightly polluted :

6-20 \WPI : None

WPI >20 : None

3.3 Irrigation water quality parameters assessment for 34 stations using Permeability Index (PI) and Sodium ADS Ratio are given at Table 3 .1 c.

1. **Permeability Index of < 60 per cent –good water and suitable for irrigation** and
2. **PI > 60 per cent- poor quality water and unsuitable.**

Inference: only 8 stations underlined in Table 3.1.c show PI of more than 60 percent, hence unsuitable for irrigation.

3. **SAR of water-suitability:**

<10 Low sodic water- can be used for irrigation

10.1-18.0 Medium sodic water –present an appreciable sodium hazard plus high cation exchange capacity

18.1-26 High sodic water-may produce harmful levels of exchangeable Sodium in most soils

>26 very high sodic water- unsatisfactory for irrigation purpose

Inference: All the 34 stations showed SAR of less than 10, hence suitable fo irrigation purpose.

3.4 Case studies of treatment plants were reviewed for criterion of climate resilient water security and the results are reviewed and presented at Table 3.2. Compliance to the guidelines are marked. Two of the successful decentralized waste water treatment plants are plants flow diagram, and a banana harvested from a greywaer wet land at a residential home are available at Fig 3.2.1 and Fig 3.2.2.

4.0 Recommendations

Based the relevant global and local best practices learnt the recommendation are drafted. Professional on job experiences related to water security has been gained for over over three decades . This experience was as a professional career as a planner, designer, estimator, tendering, execution and maintenance of water and wastewater systems for space centres in India.

Relevant wisdom or learning for climate resilient water security at Bengaluru Urban can be drawn from

- Integrated Mission on Sustainable Development IMSD, NNRMS,ISRO.
- Sujala Watershed Project, M&L,Anthariksha Corporation,ISRO (Sujala, 2002+)
- Mysuru Urban Development EO and GIS for Urban Governance (Prabhuraj, 2013),

1. EPA 1986 and related statutory requirement of effluent standards

were the primary cause for erecting the treatment plants.

a. Need for EST Environmentally Sound Technology and Circular systems in statutory level regulation for climate resilience essential.

2. A significant self reliance on water security with economical advantages is present in the treatment of waste water. This is providing a relief and reduce extra stress on the fresh water demand.

a. The Carbon credit and Carbon foot print must be taken up with water auditing in all water users.

3. Regular self appraisal and compliance reports were submitted to KSPCB.

a. Best practices linked to water recycle, reuse and reintegration necessary, Grey water decentralized treatment can release enormous quantity of water and unnecessary haulage of sewage and urban runoff ,

4. WATCHIT is a simple and reliable tool for WQM

a. AI, IOT and Biological Monitoring involving academic and civic society can empower water security.

5. The UN IETC for Environmentally Sound Technologies and and Ecological Engineering are not fully integrated to planning and design process in urban infrastructure projects.

a. The pervious areas levels much above the impervious surfaces in all paved areas

b. **Enormous decarbonization in urban storm water management is warranted**

6. The Environmental Management System with Climate Resilience is not a choice but a limit.

a. Conventional EIA,EMS,LCA are pretty well known and practiced as per the policy and compliance criterion,

b. Building Carbon foot print mechanism to performance is vital.

7. The standards fixed by the NGT over a period of time in the recent few years is good but not adequate,

a. Federal directives in Japan make it mandatory to monitor hazardous chemical species in drinking water at local levels.

b. Refurbishment standards along with complaisance necessary..

8. A definite policy at the top management and commitment at lowest level is necessary.

a. Indian Railways having a 30 percent efficiency target in water conservation by 2030 is an example.

b. Incentives for Carbon foot shall be followed in waste water,

9. O +M of the treatment plants must be by trained personnel.

a. A standard O+M manual for all STT/ETPs are necessary,

b. WHO technical format could be easy way for local context.

10. There is a need of ETP/STP HRD Capacity building.

a. The Skilled manpower is the backbone of a successful waste water management.

b. A need assessment on the manpower and and training are necessary.

These recommendations are not exhaustive and based on the organization action plan could be planned and implemented.

Enabling community to care for its water security, is suggested for all organizations responsible as stakeholders in water security at Bengaluru urban. security,

1.Caring for Earth is a pioneering strategy document evolved after a significant survey and released by IUCN/ UNEP/WWW in 1991. Six specific action plans are proposed by the document for enabling the community(Munro, 1991), They are .

Action : 01 : Provide Communities and individuals with access to resources and an equitable share in managing them.

Action : 02 : Improve exchange of information, skills, and technologies

Action : 03 : Enhance participation in conservation and development

Action : 04 : Develop more effective local governments.

Action : 05 : Care for the local environment in every community

Action : 06 : Provide financial and technical support to community environmental action.

Additional Links for Further Information and Networking for a vision, agenda and action plan for climate resilient water security for Bengaluru Urban:

https://worldwaterweek.us2.pathable.com/meetings/virtual/pHiziWWWvkhf3 Y8kw
https://wedocs.unep.org/20.500.11822/8258
https://www.un.org/waterforlifedecade/water_and_energy.shtml
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Egypt
Schipper Lisa, F 2022. Climate resilient development pathways in IPCC WGH Sixth Assessment Report pp 1-197, www.ipcc.ch, 2022
https://iees.ch/sustainable-urban-water-systems/
https://www.kscst.org.in/essaysonbangalore.html Home Page Publication
https://www.isro.gov.in/sites/default/files/respond_basket_2022.pdf
https://karunadu.karnataka.gov.in/ldakarnataka/Documents/LakeReport_26thFeb2011.pdf
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https://www.researchgate.net/publication/250061450_

https://www.thenewsminute.com/article/why-bengalurus-sewage-treatment-plants-may-never-be-enough-city-93663

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https://kspcb.karnataka.gov.in/sites/default/files/inline-files/new%20stp%20G.pdf

https://karunadu.karnataka.gov.in/ldakarnataka/pages/home.aspx

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https://www.atree.org/node/413

https://www.ijser.org/researchpaper/Assessment-of-Surface-Water-Chemistry-of-Jakkur-Lake-Bangalore-Karnataka-India.pdf,

https://indianrailways.gov.in/railwayboard/uploads/directorate/Environment_Management/Water_policy.pdf

https://www.scribd.com/document/96103697/Urban-Floods-in-Bangalore-and-Chennai

https://www.iitr.ac.in/wfw/web_ua_water_for_welfare/water/WRDM/CGWB_GW_Senario_in_Indian_cities_May_2011.pdf

https://www.cpcb.nic.in/GeneralStandards.pdf

https://www.indiawaterportal.org/articles/groundwater-hydrology-and-groundwater-quality-and-around-bangalore-city-department-mines

https://phedharyana.gov.in/WriteReadData/WSSO/Manuals/Manual%20on%20sewage%20and%20sewerage%20treatment_CPHEEO_MoUD_%201993.pdf, pp

https://bengaluru.citizenmatters.in/4179-depleting-groundwater-whos-responsible-4179

https://watershedmonitoring.com/about-us/

https://nidm.gov.in/PDF/pubs/handbook_pdna.pdf

https://empri.karnataka.gov.in/storage/pdf-files/ccc/ksapcc%20.pdf

http://www.cwc.gov.in/water-resources-information-system-wris

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5.0 Acknowledgement :

Sincere thanks are placed on record to Dr A S Kiran Kumar, Former Chairman ISRO and Dr K Ganesh Raj, DD RRSSC, NRSC ISRO for timely and motivating to further studies. Sincere thanks also to Dr. Dasarathy, Chairman, and Head, Civil Engineering Dept, JAIN(Deemed-to-be University) and colleagues at ISRO and JAIN who provided the required confidence and encouragement. Sincere thanks to all the case study departments and working personnel who readily shared the data for completion of the study which is responsible for this contribution.

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WATCHIT.EXE OUTPUT FILE

Area & Cluster Names : Bengaluru URBAN GROUP-1

Master Table. 3.1a. Physio-Chemical Properties of water and their parameters significance

Sl No	Station Name	TDS(ppm)	EC(mmhos/Cm)	pH	T(Deg.C)
01	Anekal Village	463.39	724.05	8.00	25.00
02	Attibale Village	1429.39	2233.42	7.45	25.00
03	Chandrapur V	1399.46	2186.66	7.35	25.00
04	Jigini Village	1235.79	1930.92	7.85	25.00
05	Banneraghatta V	721.34	1127.10	7.86	25.00
06	Sarjapur Village	463.39	724.05	7.50	25.00
07	Yelahanka Village	841.93	1315.72	7.80	25.00
08	H Kempapura V	485.16	758.06	7.70	25.00
09	Jalahalli Village	685.54	1071.16	7.70	25.00
10	Rajanakunte V	842.54	1316.47	7.60	25.00
11	Sadashivanagar	242.71	379.24	7.50	25.00
12	Adakamaranahalli	1120.00	1750.00	7.60	25.00
13	Chikkabanavara	1497.55	2339.92	7.70	25.00
14	Sondekoppa	1096.62	1713.47	7.60	25.00
15	Thimmenahalli	615.31	961.42	7.60	25.00
16	Bydarahalli	847.55	1324.30	7.50	20.00
17	High Court	728.73	1138.64	7.60	25.00
18	Thotagere	682.59	1066.55	7.5	25.00
19	Balagunte	804.34	1256.79	7.50	25.00
20	Laggere	1529.40	2389.69	7.60	25.00
21	Talghattapura	609.49	952.33	7.60	25.00
22	Beguru	859.45	1342.89	7.60	25.00
23	Patangere	606.48	947.63	7.60	25.00

24	**Doddakanan Halli**	**1330.41**	**2078.77**	**7.60**	**25.00**
25	**Mahadevapura**	**1018.28**	**1591.07**	**7.60**	**25.00**
26	**HSR Layout**	**820.38**	**1281.85**	**7.60**	**25.00**
27	**Avalahalli**	**598.11**	**934.55**	**7.60**	**25.00**
28	**Marenahalli**	**782.39**	**1222.49**	**7.60**	**25.00**
29	**Thavarekere**	**895.54**	**1399.29**	**7.60**	**25**
30	**Kethohalli**	**440.50**	**688.29**	**7.60**	**25.00**
31	**Manduru**	**1017.33**	**1589.58**	**7.60**	**25.00**
32	**Deevarbeesanahalli**	**700.73**	**1094.89**	**7.60**	**25.00**
33	**K.Narayapura**	**485.16**	**758.07**	**7.60**	**25.00**
34	**Kalkere**	**953.82**	**1490.35**	**7.60**	**25.00**

Table. 3.1.b Industrial Water Quality Parameters assessment for 34 stations

Sl No	**Station Name**	**RHYZNER S-INDEX**	**AGGRESSIVE INDEX**	**POLLUTION INDEX**	**POKORIUS S-INDEX**	**LARSON-SKD INDEX**	**KELLY'S RATIO**
01	**Anekal Village**	**6.68**	**12.52**	**2.3**	**6.9O**	**0.60**	**0.42**
02	**Attibale Village**	**5.93**	**12.77**	**2.51**	**4.91**	**1.46**	**0.80**
03	**Chandrapur V**	**6.13**	**12.62**	**2.26**	**5.24**	**3.15**	**0.22**
04	**Jigini Village**	**5.86**	**13.00**	**2.81**	**5.43**	**1.7**	**0.31**
05	**Banneraghatta V**	**6.57**	**12.62**	**2.54**	**6.45**	**1.75**	**0.60**
06	**Sarjapur Village**	**7.38**	**12.02**	**1.91**	**6.90**	**0.60**	**0.42**
07	**Yelahanka Village**	**6.29**	**12.74**	**2.68**	**5.89**	**1.39**	**0.27**
08	**H Kempapura V**	**7.62**	**12.00**	**2.25**	**7.65**	**1.70**	**0.70**
09	**Jalahalli Village**	**7.02**	**12.32**	**2.57**	**6.91**	**1.95**	**0.28**
10	**Rajanakunte V**	**6.44**	**12.57**	**2.35**	**5.94**	**1.57**	**0.21**
11	**Sadashivanagar**	**8.67**	**11.35**	**0.96**	**8.78**	**1.32**	**0.45**
12	**Adakamaranahalli**	**6.15**	**12.73**	**2.59**	**5.56**	**0.88**	**0.21**
13	**Chikkabanavara**	**5.48**	**13.12**	**2.67**	**4.65**	**1.53**	**0.33**
14	**Sondekoppa**	**6.13**	**12.73**	**2.60**	**5.34**	**1.22**	**0.41**
15	**Thimmenahalli**	**6.85**	**12.35**	**2.15**	**6.42**	**1.11**	**0.37**
16	**Bydarahalli**	**6.58**	**12.44**	**2.15**	**5.67**	**0.66**	**0.23**
17	**High Court**	**6.91**	**12.33**	**2.18**	**6.30**	**0.93**	**0.69**
18	**Thotagere**	**6.95**	**12.25**	**2.14**	**6.23**	**0.86**	**0.27**
19	**Balagunte**	**6.71**	**12.38**	**2.42**	**6.05**	**1.22**	**0.39**
20	**Laggere**	**5.85**	**12.89**	**2.84**	**5.01**	**1.78**	**0.56**
21	**Talghattapura**	**7.32**	**12.11**	**2.18**	**6.85**	**0.89**	**1.10**
22	**Beguru**	**6.5**	**12.54**	**2.20**	**6.13**	**2.54**	**0.50**

23	Patangere	6.93	12.31	2.30	6.47	1.03	0.55
24	Doddakanan Halli	5.83	12.89	2.53	4.97	1.38	0.49
25	Mahadevapura	7.08	12.26	2.54	6.73	3.28	0.61
26	HSR Layout	6.95	12.31	2.37	6.26	0.98	0.43
27	Avalahalli	7.34	12.10	2.24	6.91	1.11	0.96
28	Marenahalli	6.55	12.51	2.21	5.80	0.65	0.29
29	Thavarekere	6.08	12.75	1.86	5.27	0.77	0.33
30	Kethohalli	7.77	11.87	2.16	7.66	1.39	0.49
31	Manduru	6.48	12.56	2.33	5.64	0.97	0.25
32	Deevarbeesanahalli	6.96	12.30	2.33	6.46	1.3	0.47
33	K.Narayapura	7.23	12.15	2.07	6.77	0.59	0.61
34	Kalkere	6.48	12.55	2.49	5.85	1.66	0.17

Table. 3.1.c Irrigation Water Quality Parameters assessment for 34 stations

Sl No	Station Name	PERMEABLE -- INDEX	SODIUM ADS RATIO
01	Anekal Village	60.1422	1.26
02	Attibale Village	58.0039	3.83
03	Chandrapur V	28.6272	1.37
04	Jigini Village	38.0824	1.54
05	Banneraghatta V	55.7673	2.15
06	Sarjapur Village	60.1422	1.26
07	Yelahanka Village	39.8168	1.17
08	H Kempapura V	63.0121	1;99
09	Jalahalli Village	37.6403	1.12
10	Rajanakunte V	34.1802	0.96
11	Sadashivanagar	65.2482	0.99
12	Adakamaranahalli	28.7056	1.19
13	Chikkabanavara	38.4732	1.93
14	Sondekoppa	46.4012	1.94
15	Thimmenahalli	50.4942	12.35
16	Bydarahalli	41.7133	0.98
17	High Court	63.1409	2’40
18	Thotagere	45.4431	1.05
19	Balagunte	45.4431	1.05
20	Laggere	47.9015	3.01
21	Talghattapura	77.1551	3.12

22	Beguru	47.9958	2.06
23	Patangere	59.7573	1.83
24	Doddakanan Halli	47.0854	2.49
25	Mahadevapura	49.7376	2.71
26	HSR Layout	51.0104	1.72
27	Avalahalli	71.6936	2.86
28	Marenahalli	46.7827	1.2
29	Thavarekere	46.0490	1.45
30	Kethohalli	57.2251	1.43
31	Manduru	37.8679	1.2
32	Deevarbeesanahalli	53.1136	1.75
33	K.Narayapura	71.3229	1.68
34	Kalkere	30.4904	0.82

Table 3.2.1 Summary of review of selected case studies for Climate Resilient Urban Water Security for Bengaluru(CRUWSB)

Sl No,	Capacity KLD, Organization, Year of commissioning	UNIPCC 2021 Ten pathways Note : 1	UN IETC 1992 EST Technology Note :2	Ecological Engineering Principles Note: 3	N EPA 1986, MoEF&CC 2017 Note :4	Compliance to KSAPCC 2013 and 2021 Note: 4	Remarks, Scope for furthering performance for CRUWSB
1	1 No FSTP 6KLD, Devanahalli	*6 and *10	*1,*3 and *10	*1,*2 and *3	*1	*1f	Replication in unanswered urban region.
2,3	2 Nos 1MLD, 250MLD,ISRO	*6	*1,*3 and *10	*3	*1	*1f,*2a	Recharging RW using trees and drains
4,5,6	3 Nos, 60,5 AND 1.5 MLD BWSSB,	*10	*1,*3 and *10	*1	*1	*1a,f	Geospatial temporal data for WQM in tanks at Kolar
7,8,9	3 Nos 1 Nos MLD, 2 Nos 400 KLD,400 SWR	*6	*1,*3 and *10	*2	*1	*1a,f,g,*2a	Water intensive washing could be replaced by foam
10,11,12,13	4 Nos 450,200,300,75 HAL, 2021-22	*6 and *10	*2 and *3	*1	*1	*1f	Scope for reuse and recycling in closets and urinals
13, 14	2 Nos NACIN, 40 KLD , Trees Recharge						

15,16,17,18	2 Nos ETP 100 KLD and 2 Nos STP 55 KLD, METRO, Bengaluru	*6 and *10	*1,*3 and *10	*1 and *2	*1	*1a,c,*2a	Horticulture and flushing the closets and urinals
19	1 No, BIAL Water Security System	*6 and*10	*1,*2,*3	*3	*1	*1 and *2	Treated effluent for flushing
20	Atal Bhoojal GW Recharge Whole State	*10	*3	*2	* Recharging	*1 and *2	Ground water recharge
21	Household grey water recycling: 0.75MX3.5MX2,2.5 M	*6,*8 and *10,	*1,*2 and *3	*1,*2 and *3	* Polishing grey water	* Water conservation	Dual system of piping in position for flushing WC in toilets

Compliance Criteria for Evaluating the Climate Resilience Water Security

Note: 1 : UN IPCC 2022 Pathways criteria for CRUWSB : 6. Changing home behavior is an important but often overlooked climate action opportunity. 8. Nature-based solutions are essential for getting there, but read the fine print. 10. The costs of climate change mitigation are justified by the benefits to human and natural health.

Note:2: UN IETC, 1992 for CRUWSB : Environmentally Sound Technologies (ESTs) criteria for CRUWSB 1) Significantly improved environmental performance technologies.2) Protect the environment, are less polluting, use resources in a sustainable manner, recycle more of their wastes and products, and handle all residual wastes 3) ESTs are not just individual technologies (UN IETC 1992)

Note :3: EE, 1990 for CRUWSB, Ecological engineering 1) as the design with its natural environment for the benefit of both. 2) It is engineering in the sense that it involves the design of this natural environment using quantitative approaches and basing their approaches on basic science.3) It is a technology with the primary tool being self-designing ecosystems(Mitsch and Jorgensen 1989)

Note:4: EPA 1986 and NGT19 CRUWSB: Discharge standards**: 1)EPA 1986 :** BOD <30 mg/l, COD<260 mg/l, TSS<100mg/l, Ammonical N <50mg/l , TN<100 mg/l, 2) **MoEF&CC 2017 Notification** BOD <20 mg/l, TSS<50mg/l, Ammonical , Faecal Coliform(MPN) < 1000.

Note:4: KSAPCC 2013 and 2021 for CRUWSB: KSAPCC 2013: 1) Water Policy, a) RWH Act 2009 b) GW Protection c) Sewage Management d) Lakes e) National Water Mission, f) Waste water treatment plants for all sectors g) Water audit h) Sustained water literacy 2) KSAPCC 2021:a) Institutional engagements and stakeholders participation and b) Capacity building for Climate adaptation.

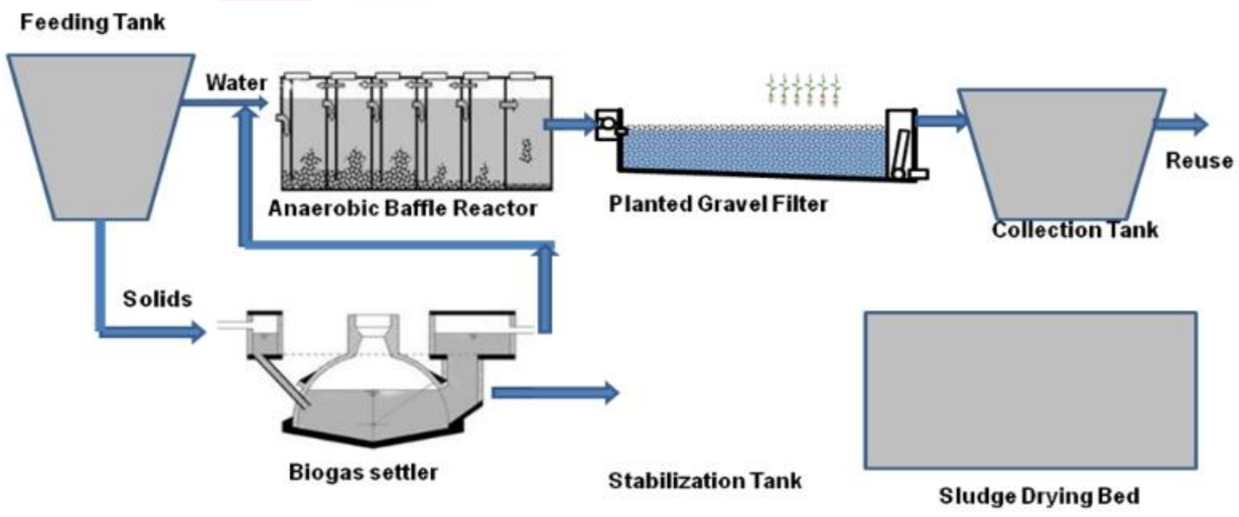

Fig : 3.2.1 Flow Diagram Faecal Sludge Treatment Plant, 4.5 Cum/day

Image : 3.2.1 : Banana Fruit grown in a wetland at a Residential home in urban having size 0.75 MX 3.5MX2,25M