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International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Volume 13, Issue 12, December 2024

Studies on Conservation and Management of Lakes and Reservoirs

(A Case Study on Byramangala Lake, Magadi Taluk, Ramangaara District, Karnataka,India)

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Abstract
Water is susceptible to get contaminated by any foreign matter and this may be either natural or artificial. Any alteration in the physical, chemical and biological properties of water as well as contamination of any foreign substances leads to health hazard. The polluted natural water resources are hazardous to aquatic life and also to human life. The major sources of water pollution are domestic waste from urban areas, rural areas and industrial wastes, which are discharged into natural water bodies.

Reservoirs and lakes occupy a prominent place in the history of irrigation in South India. Tanks are considered to be useful life saving mechanism in the water scarcity areas which are categorized as Arid and Semi-arid zones. The lakes and reservoirs, all over the country without exception, are in varying degrees of environmental degradation. The degradation is due to encroachments, eutrophication and siltation. There has been a quantum jump in population during the last century without corresponding expansion of civic facilities resulting in deterioration of lakes and reservoirs, especially in urban and semi urban areas becoming sinks for the contaminants. The degradation of reservoir and lake catchments due to deforestation, stone quarrying, sand mining, extensive agricultural use, consequent erosion and increased silt flows have vitiated the quality of water stored in the reservoirs. The study area vie., Byramangala reservoir catchment has an areal extent of 340 sq.km,and command area of 28 sqkm It is encompassed by East longitude 77^0 23'45"- 77^0 34'16"and North latitude 12^0 45' 00"- $13^0$02' 40"at a distance of about 40 km from Bangalore.

The paper discusses the physico-chemical and bacteriological studies carried out on surface and ground water and soil in the Byramangala reservoir catchment and the command area. The surface water and ground water in the catchment and command areas were subjected to qualitative analysis for its physical, chemical and biological characteristics. The sampling was done at a monthly interval of three months, i.e., in the month of April2012, September2012, and January 2013.The results of analyses of water samples reveal that water is polluted at certain locations. The max and min values of BOD are 108 mg/l and 48.5mg/l, the COD 264mg/l and86.3mg/l, TDS 1691mg/l and 990 mg/l, DO are 2.5ppm to 1.2 ppm, Water quality Index between 289 to 112.The presence of heavy metals such as Fe, Mn, Zn, Cu, Pb, Cr in vegetation and soil of command area is beyond the permissible limits at certain locations. The total–coliform and faecal-coliform in ground water and surface water at certain locations and reservoir varies between $64x10^4$/100ml to9600/100ml which indicates that water is highly polluted with domestic and industrial effluents. Techno-ecological approaches such as Soil scrape filter, Succession pond, Green lake technology, Green bridge technology will help to reduce pollution levels in the Byramangala reservoir, its catchment and command areas.

KeyWords: **Urbanization , Reservoir, Irrigation Techniques, Lake Management**

INTRODUCTION

Water is considered to be an essential input in agriculture and its quality is of paramount importance for successful rising of crops and aquatic life. Poor quality of water apart from having direct detrimental effect on crop growth also affects indirectly on physico-chemical properties of soils, which further leads to ground water pollution. Hence there is need to protect ground water.

The water body selected for purposes of assessment of physic- chemical and biological characteristics of surface water of the Byramangala tank located 40 kilometers away from Bangalore which receives both treated and untreated waste water disposed of from Bangalore urban locality. The lake water is subjected to qualitative analysis

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Published by :
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International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
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for its physical, chemical and biological characteristics. Five samples were collected at a time: one kilometer distance prior to the lake, near the inlet of the lake, near the lake weir, near the northern side of the lake, and near the channel where water is used for irrigation.

All the 28 parameters considered include pH, temperature, turbidity, conductivity, dissolved oxygen, BOD, COD, Suspended solids, Dissolved solids ,Sodium, Potassium, Calcium, Magnesium, hardness, Total alkalinity, Chloride, Fluoride, Nitrate, Phosphate, Sulphates. Hexa-Chromium, Iron, Copper, Lead, Zinc, Nickel, Total-Coliform, Faecal Coliform. The analysis was done as per the Bureau of Indian Standards (BIS) and Standard methods as prescribed by AWWA. The soil samples were collected at two different spots fed by this polluted tank and analysed for the presence of micronutrients and macro nutrients. Soil is a complex mixture of mineral matter, organic matter and living organisms. The physical properties of soil largely determine the suitability of soil for the growth of a particular crop. Soil nutrients can be classified into macro and micro nutrients. Nitrogen, Phosphorous, Potassium are generally in the manure and fertilizers and are called fertilizer elements. Iron, Zinc, Copper, Manganese, Boron Molybdenum are micronutrients. Each nutrient plays a specific role in the growth and development of crop and when present in insufficient quantities the growth and, crop yield may be reduced considerably as the deficiency of anyone of it makes impossible for the plant to complete its life cycle.

STUDY AREA

The Vrishabhavati a fourth order upstream drains an aerial extent of 545 sq. Km before it joins Suvarnamukhi river at Bhadragundamadoddi (North latitude 12^0 39' 40" and East longitude 77^0 25' 00") of Kanakapura taluk. The river Suvarnamukhi is one of the major Tributaries of the river Arkavathi in Karnataka part of the Cauvery Basin. But, the study area is sealed down to the Vrishabhavathi stream system terminating at Byramangala tank. This has an aerial extent of 340 sq.Km. It is encompassed by East longitude 77^0 23'45"- 77^0 34'16" and North latitude 12^0 45' 00"- $13^0$02' 40". The topographic coverage of the area is in the survey of India topographic maps No. 57 H/5, H/9 and G/12 on scale 1:50000.

Fig 1 Satellite Image of Byramangala reservoir

Byramanagala tank is located in Bidadi Hobli of Ramanagaram distsrict. The catchment of reservoir includes Bangalore urban areas which comes under Bhruhauth Bangalore Mahanagara Palike and villages of Bangalore rural area, Rajajinagar Industrial area, Peenya Industrial area and Kumbalgod Industrial area and the Bidadi Industrial are located in this Reservoir catchment area,. The Vrishabhavathi river which runs in the catchment carries urban domestic sewage, Industrial sewage and storm water from urban, semi urban and rural areas. The agricultural wastes resulting from intensive farming in the rural areas of the catchment also enter the reservoir. The study reveals that the reservoir is highly polluted and the Reservoir sediments are also contaminated. The annual rainfall data of 789mm and average monsoon rainfall of 551.69mm were collected from the records of the rain gauge installed at Byramangala. The minimum annual inflow to the reservoir is 23.92M^3 and maximum annual inflow is 114.5x10^9 M^3. The withdrawal from canal is recorded as 34.97M cum and the reservoir losses are noted up to 5.42M cum. The details of reservoir indicated FRL as 24.10Mm^3, live storage at FRL as 22.01Mm^3, dead storage at sill level of sluice as 2.09Mm3 and water spread area at FRL as 430.25ha. The spillway of reservoir is of broad crested type located at right flank. The length of spillway is of 150.5m, its flood lift is recorded as 0.9m and discharge capacity is of 230cumecs.The bund constructed for Byramangala reservoir is of earthern type and its height at the deepest point is recorded as 22.85m. The length of the bund is recorded as 2286m and top width of the bund as 3.66m. The MWL of the reservoir is noted as 32.9m its FRL as 32m and its sill level as 22.85m.The Reservoir is provided with 2 channels,viz., Left Bank canal and Right bank canal. The left bank canal is 26.4 km length and Right bank canal is 8.4 km length having a command area of 1330 ha and right bank canal is 8.4 km having a command area of 444ha. Reconnaissance survey reveals that the soil in the command area is polluted with the application of sewage water.

Fig 2 Polluted water flowing through the Left Bank channel

Geology and Geomorphology of the study area

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International Journal of Engineering Research & Technology (IJERT)
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At the head reaches, the Southerly flowing Vrishabhavathi flows at the head reaches over the laterite profile. From the sources of origin upto N13^0 parallel, the stream flows on deep chemically weathered saprolite profile. Downstream of N^0 13 parallel and up to the road bridge to the SSE of the Kumbalagodu (E 77° 27' : N 15°52'20")it flows over the banded gneissic suite of formation. Beyond Kumbalagodu, the stream cuts and flows through granitic gneiss dipping steep easterly. On the left bank, the granitic gneisses are traversed by parallel system of basic dykes which are trending NW – SE. In the lower reaches of the stream near Byramangala tank, these basic dykes cross over to the right bank with well marked evidence of off – setting ; suggesting this span of the stream flow is trained by NE – SW system of faulting. The water divide separating the Vrishabhavathi from the Arkavathi river system is marked by regional N-S fractures that are implaced by dykes. The main stream of Vrishabhavathi finds its source on the South-East slope of topographic point 926m to the NNE of Peenya. It flows southwards through Rajajinagar of Bruhat Bangalore Mahanagara Palike (BBMP). The urbanization in the area has distorted the flow course of the first and the second order streams and also the original course of Vrishabhavathi River in certain pockets. The present setting of the main stream has a definite landscape. It maintains a well carved landscape in the downstream and gets drained by subsidiary drainages. Prominent among these tributaries is the 'Nagarabhavi torai'. Distortion of the original drainage course at upstream of Kumbalagodu owing to urbanization has resulted in not exhibiting or well integrated special pattern of the stream system. Distinct evidence of the stream system having been structurally controlled is noted in the downstream part of Kumbalagodu. The main stream has carved out a deep rock cut valley between Kumbalagodu and Ampapura. The land use and land cover map is shown in fig 3.

METHODOLOGY

The water samples were collected during the month of April 2012(Pre Monsoon), September 2012(Monsoon), and December 2013(Post Monsoon) at various locations in the reservoir , its catchment and command areas. The Samples were subjected to Physico-Chemical and Bacteriological analysis. . For ground water source, water samples were drawn from tube wells located in the study area. The Physico-chemical and biological analyses were carried out for the watersamples collected from various locations using standard procedures recommended by APHA-1994. The soil samples were analyzed for micronutrients, macronutrients, p^H and % organic carbon. The soil samples and vegetation samples collected from the catchment and command areas are subjected to analysis of heavy metals and there uptake from soil to vegetation. The spatial analyses of water and soil samples collected were carried out using GIS-Arc Info Soft ware. The water samples were analyzed for Irrigation water requirements and water and soil quality index were calculated for the Samples collected in the catchment and command areas.

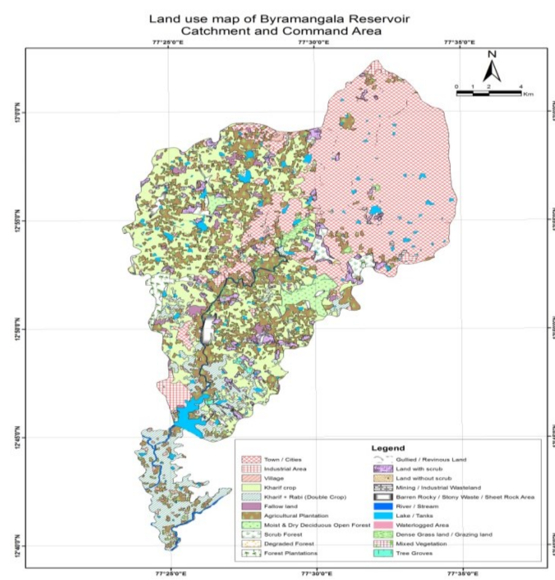

Fig 3. Land use and Land cover map of Byramangala Reservoir catchment and command area.

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RESULTS AND DISCUSSION.

The surface water and ground water samples were analyzed for three seasons at 42 locations in the catchment and command area. The results of Physco-Chemical and Bacterialogical studies in ground water and surface water water of Byramangala reservoir catchment and command area reveals that surface and ground water is contaminated at various locations. High concentrations of Sodium, calcium, magnesium, chlorides, sulphates, nitrates, bicarbonates and hardness were observed in the ground water samples beyond permissible limits. The BOD, COD, Total –coliform, Faecal- Coloform were found to be very high in surface water samples. The surface and ground water were also tested for heavy metal concentration. Heavy metals such as copper, zinc, lead, nickel and iron were observed in the surface water samples of Byramangala reservoir and vrishvabhavathi river flowing into the reservoir.The results of seasonal analysis of surface and ground water samples were presented in table 3. The spatial distribution of TDS in the ground water samples is shown in fig 5.Thes results of Chemical analysis of soil samples collected in the catchment and command area reveals that Lower values of available Phosphorus and available potash and organic carbon soil samples.

The presence of heavy metals such as Fe, Mn, Zn, Cu, Pb, Cr in vegetation and soil of command area is beyond the permissible limits at certain locations.The results of heavy metal concentration in cultivated vegetation is shown in table 2.The metal transfer factor for each metal from soil to vegetation was calculated and tabulated in table 1and Fig5 It is also observed that average levels of metal concentration(µg/l) in lake water ie., 1015(Fe), 115(Zn), 16(Cu),4(Ni), 3 (Cr) , 8 (Pb),and 0.5(Cd) were 2,8,3,5,4,8 and 20 –fold higher than the natural elemental levels 500 (Fe), 15(Zn), 3(Zn),0.5(Ni),1(Cr),1(Pb) and0.03(Cd) in fresh water respectively.

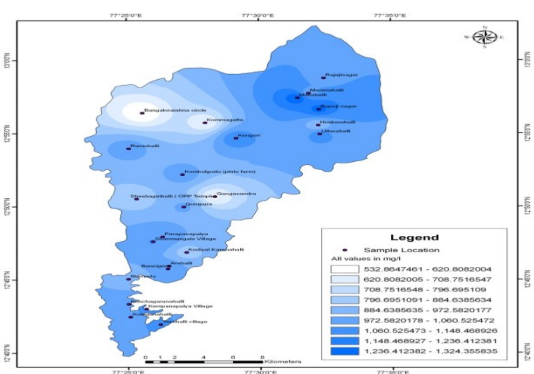

Fig 4 Spatial distribution of TDS in the ground water samples of the reservoir catchments and command area.

Table 1. Metal transfer factor for each metal from soil to vegitation

Heavy metal	Brinjal	Mulberry	Sapota	Raddish	Maize	Ragi	Fodder
Fe	**7.9**	**8.8**	**2.7**	**37.6**	**2.38**	**5.73**	**71.43**
Mn	**0.71**	**1.1**	**1.9**	**0.56**	**0.87**	**1.78**	**0.91**
Zn	**8.5**	**4.59**	**1.4**	**12.89**	**3.92**	**7.34**	**8.54**
Cu	**3.6**	**1.52**	**0.63**	**1.5**	**2.77**	**1.11**	**1.98**
Pb	**2.56**	**2.15**	**1.14**	**2.78**	**5.33**	**2.86**	**1.66**
Cd	**3.48**	**4.33**	**1.6**	**26.04**	**3.03**	**8.33**	**-**

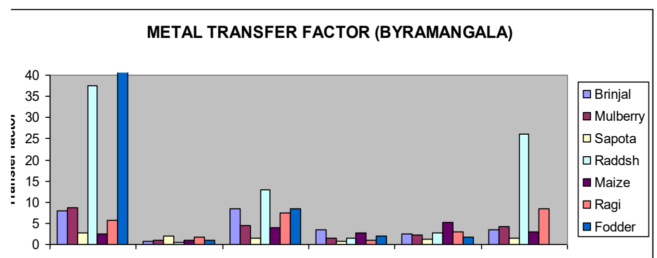

Fig 5. Metal transfer factor for each metal from soil to vegetation

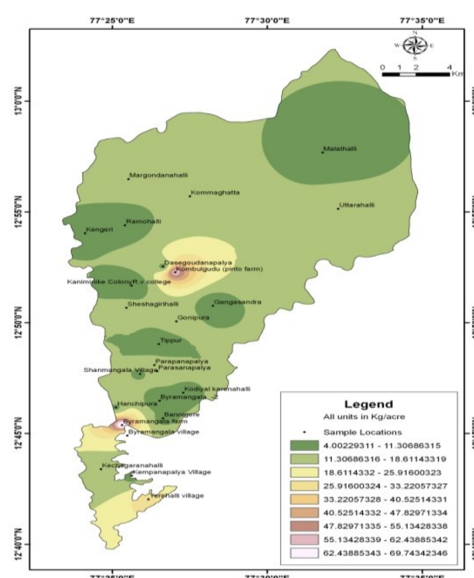

Fig 6. Spatial distribution of Available Phosphorous in the soil samples of the catchment and command area

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International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Volume 13, Issue 12, December 2024

Table 2. Results of presence of Heavy metals in vegetables of Byramangala command area.

Sl.no	Name of the sample or Vegetation		Iron(Fe) in µgm/Kg		Manganese(Mn) in µgm/Kg		Zinc(Zn) in µgm/Kg		Copper(Cu) in µgm/Kg		Chromium(Cr) in µgm/Kg		Lead(Pb) in µgm/Kg		Cadmium(Cd) in µgm/Kg	
			IS	Result	IS	Result	IS	Result	IS	Result	IS	Result	IS	Result	IS	Result
1	Brinjal	Soil	500	78.83	50	48.39	49	1.9	30	2.31	20	0	1.8	0.94	2.2	0.273
		Root	500	1978.08	50	34.7	49	28.05	30	8.55	20	0	1.8	0.25	2.2	0.95
		Leaf	500	623.4	50	14.3	49	16.15	30	4.9	20	0	1.8	0.6	2.2	0.05
		Fruit	500	41.85	50	7.45	49	23.15	30	8.5	20	0	1.8	1.25	2.2	0.7
2	Mulberry	Soil	500	5.71	50	35.13	49	2.57	30	3.09	20	0	1.8	0.72	2.2	.003
		Root	500	2142.12	50	37.2	49	11.8	30	3.7	20	0	1.8	1.55	2.2	0.45
		Stem	500	50.25	50	9.45	49	37.85	30	4.7	20	0	1.8	0.65	2.2	0.05
		Leaf	500	151.7	50	39.1	49	17.75	30	3.7	20	0	1.8	0	2.2	0
3	Sapota	Soil	500	26.01	50	27.68	49	6.56	30	6.94	20	0	1.8	0.96	2.2	0.093
		Root	500	1680.72	50	52.6	49	13.7	30	3.05	20	0	1.8	1.85	2.2	0
		Stem	500	70.3	50	10.95	49	9.2	30	1.15	20	0	1.8	1.3	2.2	0.15
		Leaf	500	30.55	50	27.2	49	15.8	30	4.4	20	0	1.8	1.1	2.2	0
		Fruit	500	33.3	50	4.05	49	5.45	30	0.55	20	0	1.8	0	2.2	1.1
4	Radish	Soil	500	12.53	50	53.88	49	1.47	30	1.96	20	0	1.8	1.06	2.2	0.048
		Leaf	500	473.95	50	30.35	49	32.4	30	5.55	20	0	1.8	2.95	2.2	0
		Fruit	500	1669.36	50	27.5	49	18.95	30	2.95	20	0	1.8	6.95	2.2	1.25
5	Maize	Soil	500	16.31	50	70.52	49	3.02	30	1.46	20	0	1.8	0.63	2.2	0.033
		Stem	500	53.4	50	13.7	49	12.8	30	7	20	0	1.8	3.36	2.2	0.1
		Leaf	500	135.45	50	61.4	49	29.6	30	6.55	20	0	1.8	0	2.2	0.65
		Fruit	500	38.9	50	20.55	49	47.45	30	4.05	20	0	1.8	6.1	2.2	1.3
		Fruit1	500	69.55	50	7.4	49	11.85	30	10.45	20	0	1.8	0	2.2	0.75
6	Ragi	Soil	500	7.01	50	54.53	49	1.98	30	2.92	20	0	1.8	0.68	2.2	0.036
		Root	500	7800.4	50	51.95	49	18.85	30	9.7	20	0	1.8	1.95	2.2	0.65
		Stem	500	40.2	50	31.75	49	14.55	30	2.2	20	0	1.8	6.8	2.2	0.3
		Leaf	500	163	50	97.5	49	22.55	30	3.25	20	0	1.8	0.2	2.2	1.35
		Fruit	500	70.4	50	45.1	49	39.75	30	6.15	20	0	1.8	5.9	2.2	0
7	Fodder	Soil	500	5.1	50	59.76	49	2.1	30	2.04	20	0	1.8	1.92	2.2	0
		Root	500	5795.4	50	54.85	49	17.95	30	6.9	20	0	1.8	3.2	2.2	0.4
		leaf	500	364.3	50	40.7	49	20.55	30	4.05	20	0	1.8	0.6	2.2	0
8	SugarCane	Leaf	500	119.05	50	65.65	49	10.7	30	1.4	20	0	1.8	2.95	2.2	0
9	Banana	Root	500	1525.02	50	677.75	49	29.85	30	8.9	20	0	1.8	2.4	2.2	0.95
		leaf	500	335.05	50	141	49	22.9	30	0.6	20	0	1.8	0.4	2.2	0

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International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
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Table-3 Seasonal variation of water quality parametres in the Byramangala Catchment and Command areas. (Min - Max values)

I	PARAMETERS	Ground water			Surface water (Reservoir and Stream)		
	Season	Pre-monsoon	Monsoon	Post monsoon	Pre-monsoon	Monsoon	Post monsoon
1	**pH**	**7.3-8.1**	**7.75-8.2**	**7.08- 7.81**	**8.05-8.39**	**7.2-8.53**	**7.11- 8.5**
2	**Temperature°(C)**	**29**	**26**	**24**	**29**	**26**	**24**
3	**DO(mg/lt)**	**3.7-5.9**	**5.9-6.8**	**2.4- 4.7**	**1.4-5.9**	**1.1-3.9**	**1.2-4.1**
4	**BOD(mg/lt)for 5 days**	**<1.0 – 21.6**	**<1.0-15.4**	**1.7-18.2**	**15.8 – 158.9**	**12.3-148.4**	**17.4-150.7**
5	**COD,mg/lt**	**3.6- 42.5**	**<1.0- 35.7**	**5.2-40.9**	**56.8-286.3**	**41.2-278.3**	**32.1-292.3**
6	**TSS,mg/lt**	**<1.0-8.9**	**<1.0-5.7**	**<1.0 – 7.8**	**12.4-66.6**	**11.1-68.5**	**15.9-71.5**
7	**Turbidity,NTU**	**0-6.9**	**0-5.2**	**0- 6.7**	**3.9-33.6**	**3.0-55.2**	**3.8-45.3**
8	**TDS,mg/lt**	**819- 2439**	**771-1956**	**796- 2247**	**902-1735**	**798.5-1631**	**815-1695**
9	**Conductivity,micromhos/cm @25 C**	**1498-2752.9**	**1123-2430.4**	**1227 – 2488.3**	**1278-2713**	**1128-2545**	**1112 - 2391**
10	**Sodium as Na ,mg/lt**	**98.9- 224.4**	**82.9-201..3**	**91.6-211.9**	**127.5-192.3**	**72.5-180.3**	**91.5- 91.53**
11	**Potassium as K,mg/lt**	**6.1 – 57.49**	**4.2-47.0**	**5.4-51.0**	**1.3-45.8**	**3.93-42.1**	**2.1 – 32.9**
12	**Calcium as Ca,mg/lt**	**50.2 – 221.4**	**33.2-168.7**	**61.79 - 202.4**	**72.1-171.4**	**57.3-165.4**	**65.2 – 151.9**
13	**Magnesium as Mg,mg/lt**	**19.5 – 96.2**	**13.9-68.4**	**24.40 - 98.2**	**12.2-79.4**	**16.2-86.3**	**10.7- 81.5**
14	**Total Hardness as $CaCo_3$,mg/lt**	**176.3 – 791.52**	**152.7-624.5**	**224.5 – 735.19**	**250-720.7**	**214.2-668.6**	**232.1- 715.4**
15	**Total Alkanility,as $CaCo_3$,mg/lt**	**178.4 – 645.2**	**274.0-612.3**	**264.0 – 612.3**	**312.5 – 582.3**	**283-683.5**	**302.5-539.2**
16	**Chlorides as mg/lt**	**90.7 – 329.4**	**101.5-278.9**	**112.5 –302.4**	**159-290.8**	**92.3-282.4**	**129.9-272.5**
17	**HCO_3 as mg/l**	**270.4- 625.9**	**285.4-747.1**	**293.6- 703.9**	**314.2 – 710.4**	**261.4-669.7**	**278.6- 632.1**
18	**Fluorides asF,mg/lt**	**0.56 – 1.9**	**0.28-1.7**	**0.41–2.1**	**0.02-1.15**	**0.02-1.10**	**00.5--1.18**
19	**Nitrates as No_3,mg/lt**	**5.9- 76.8**	**0.97-98.8**	**4.5- 87.8**	**7.8-97.6**	**7.2-88.4**	**7.5-81.60**
20	**Phosphorous as Po_4,mg/lt**	**<0.05**	**<0.05**	**<0.05**	**3.1-8.9**	**3.0-7.4**	**3.4-9.1**
21	**Sulphates as So_4,mg/lt**	**14.4 – 78.5**	**9.5-68.4**	**13.5 -71.9**	**9.2-55.9**	**7.0-45.2**	**8.2-40.5**
22	**Hexa valent–Chromiun as Cr6+,mg/lt**	**<0.01**	**<0.01**	**<0.01**	**0.01-0.02**	**0.01-0.02**	**0.01-0.07**
23	**Iron, as Fe ,mg/lt**	**0.09 – 7.2**	**0.04-3.0**	**0.05 – 8.1**	**0.08 – 0.57**	**0.05-0.38**	**0.09-0.39**
24	**Copper,as Cu,mg/lt**	**< 0.02-0.04**	**0.02-0.04**	**< 0.02-0.04**	**0.02-0.19**	**0.02-0.14**	**0.02-0.21**
25	**Lead,as Pb,mg/lt**	**<0.01-0.11**	**<0.01-0.19**	**<0.01-0.13**	**0.01-0.41**	**0.01-0.38**	**0.01-0.33**
26	**Nickel as Ni,mg/lt**	**<0.01-0.11**	**<0.01-0.09**	**<0.01-0.10**	**0.09-6.2**	**0.07-5.1**	**0.08-6.1**
27	**Zinc,as Zn mg/lt**	**0.02 – 0.19**	**0.02-0.25**	**0.02 – 0.16**	**0.04-0.81**	**0.02-0.77**	**0.03-0.71**
28	**Total -Coliform/100ml**	**0-32700**	**0-9600**	**0-12700**	**34-307 X10^4**	**12-228X10^4**	**42 – 208X10^4**
29	**Faecal-Coliform/100ml**	**0-14300**	**0-5800**	**0-9300**	**6-202 X10^4**	**8-182X10^4**	**7-195X10^4**

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International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Volume 13, Issue 12, December 2024

Techno-ecological methods for lake and reservoir management.

Engineering applications of ecological principles and succession of biological communities is very useful to consume organic and inorganic pollutants from the water and bioconvert them into toxic form. The consortia of organisms at different tropic levels utilize pollutant as nutrients. These eco-transformations, eco-conservations and degradations or bio utilization of pollutants-nutrients are the part of ecological cycles-bio geo chemical cycles. An attempt has been made to apply natural flora and fauna in well designed manner in Byramangala reservoir catchment areas which contributes polluted sewage inlet into the reservoir .to develop technologies like green bridge, green lake eco systems, green channel biological oxidation and stream eco systems.

(i) Soil scape filter

It is the simulation of natural filtration of water or waste water through well developed soils and fragmented rock materials below which gives purified water in the form of ground water. Soil filter contains layers of bioactive soil ECOFERT developed from non toxic and non hazardous wastes. The process harness ecological principals of interactions and interrelationships of biota with their environment and eco transformations of substrates into assimiable form by treating, transforming and detoxifying the pollutants using solar energy.

(ii) Stream eco system

It involves the use of natural slopes of the polluted drains, beds, banks of streams or ponds to enhance the aerobic activity in water by generating turbulence and providin shallow depth to allow sun-light to reach the bottom. This is the simulation of the stream flow in the wilderness. It ensures the free flow in water splashed by rocks and cascades. It is observed that the dissolved oxygen in the water increases multifold-in some already installed systems and is observed that this increases upto 90-120 times(i.e. from 0.1 to 8-12ppm)

(iii) Hydrasch succession pond

It is an application of ecological succession of aquatic plants depending on characteristics of incoming effluents. Various green plants including invasive species are successfully employed in these phytofiltration and phytoremediation process with bio remediation to treat organic and inorganic pollution. It is open water system, confined by rooting plants, surface covered by floating plants establishing a detritus food as a major components with various trophic levels flourishing depending on the limiting factor of incoming nutrients. Natural streams, rivers, and lakes have their own inbuilt purification systems, the winds, natural slopes, stones, sand, biological growth and complex food web help in the purification process. The basis of food web is nothing but utilization of one's waste by another as its food. Nature as her own living machinery of detritivorous microbes and other living species to consume wastes. These principles have been harnessed in the stream Eco-System Technology.

(iv) Phytofiltration and biox process

It involves the use of plant fibres, roots to remove suspended solids from waste water effectively in a well designed tank. In this technique normally the floating plants are used to facilitate the removal of solids by bio sorption methods. Biological oxygenation process is defined as the transfer and dissolution of oxygen with the help of certain green plants and algae. It has been observed that in the unpolluted mountain streams the oxygen content in the water rise up to 19ppm. The effect can be achieved in polluted drains using certain algal species in combination with streams ecosystem techniques.

(v) Green bridge technology

Green Bridge Technology uses filtration of biologically oriented cellulosic / fibrous materials in combination with sand and gravels and root systems of green plants. It is an innovative approach to minimize the cost of pollution treatment when the cellulosic / fibrous materials like coconut coir or dried water hyacinth or aquatic grasses are compacted and woven to form a bridge / porous wall like structure strengthened by stones and sand. All the floatable and suspended solids are trapped in this biological bridge and the turbidity of flowing water is reduced substantially. The green plants growing there help in absorption of soluble substances including heavy metals.

Green lake technologies

Green lake system uses floating, submerged or emergent aquatic plant species. These can be termed as macrophyte ponds also. Macrophyte are capable to absorb large amount of inorganic nutrients such as N and P, and heavy metals such as Cd, Cu, Hg and Zn etc. and to engineer the growth microbes to facilitate the degradation of organic matter and toxicants. Green plants detoxify the pollutants and make them suitable for other organisms.

CONCLUSIONS

Industrial waste is a major contributor to the pollution of tanks. Once the waste is disposed of into water bodies without proper treatment it renders the Reservoir water unfit for use inconsumable. The factors that affect the pollution of water depend on the type of industries, the nature of waste disposal etc. Many industries are situated in the catchment area and adjacent to the river is disposing their effluents without any primary treatment. Once these pollutants enter the water bodies it had polluted the entire reservoir and makes the water unsuitable. The most important aspect is that the illegal disposal of industrial effluent must be curbed and penalties must be levied on industries violating such rules. Every industry should

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International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Volume 13, Issue 12, December 2024

strictly adhere to the effluent disposal system by providing necessary treatment unit at the source of disposal of waste water before it is finally released into the reservoir.

Considering the above reason it is also important to note that intensive farming in the village should be reduced. In many cases it is seen that the inflow of pollution into Byramangala reservoir is from ground water, as one of the sources, hence pollution of the ground water by the source has to be eliminated. Chemical fertilizers are a major contributor to the pollution of ground water. Hence, it is recommended that biofertilizers on organic fertilizers be used for crops rather than chemical fertilizers.

Another important aspect of ground water pollution is urbanization in the Catchment area. Rapid urbanization has resulted in discharging sewage into road side drains which resulted in ground water contamination and also directly discharged in to water bodies. The sewerage system should also be well designed, the soak pits and septic tanks should be closed and the entire study are should be laid with sewers and domestic sewage should be treated in this urbanizing areas. The solid waste generated from industries should not be dumped near the water source and should be carried away and disposed of into the solid waste disposal sites specifically designed.

Even with all the measures in place, it is essential that the people should be educated about the hazards of pollution. Public awareness camps should be conducted in the study area with Industry-public interaction to educate the people to reduce problem of further contamination. In all these areas, door to door collection of garbage system should be strictly implemented.

The results of physico-Chemical and bacteriological analysis of water samples in the catchment, and command area reveals that water is highly polluted at certain areas where industrial effluents were directly discharged. Heavy metals were also detected in ground and surface water samples which were above tolerance limits. Soil samples collected has low organic carbon, micro and macronutrients. Heavy metals were detected above permissible limits in the soil and vegetation samples which were fed with reservoir water in the command area.

The cost effective and less energy intensive treatment methodology may be adopted to control the pollution emanating from point and non-point sources. The Techno-ecological treatment systems such as soil Scape filter, Hydrash succession pond, and Green bridge technology may be adopted to prevent further pollution. The Bio remediation techniques will helps in reducing the reservoir pollution. Lake management in India need a revolutionary change in the approach as they influence the local/ regional ecology, climate, agriculture and economy. The Urban lakes have additional role to play as centre of recreational activities in addition to water supply. The lake catchment management plan is essential which includes control of deforestation, control of erosion, Treatment of industrial and domestic sewage at the source

Acknowledgements: The authors wish to place on record their thanks to Management, Principal and Head of the Department of Civil Engineering of MEI Polytechnic, Rajajinagar, Bangalore, India and Management, Principal and Head of the Department of Civil Engineering of Dr.Ambedkar Institute of Technology, Malatahalli, Bangalore, India for their help and encouragement during the present research work and preparation of this paper.

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