International Journal of
Chemical, Environmental and Pharmaceutical Research

ijCEPr

Vol. 2, No.1, 34-39
January-April, 2011

Study Regarding Lake Water Pollution with Heavy Metals in Nagpur City (India)

P.J. Puri[*,1], M.K.N. Yenkie[1], S. P. Sangal[2], N.V. Gandhare[2] and G. B. Sarote[3]
[*,1]Department of Chemistry, LIT, Rashtrasant Tukadoji Maharaj Nagpur University, Nagpur - 440 001,
[1] Department of Chemistry, LIT, Rashtrasant Tukadoji Maharaj Nagpur University, Nagpur - 440 001,
[2]Department of Chemistry, Nabira Mahavidyalaya, RTM, Nagpur University, Katol - 66302
[3]Regional Forensic Science Laboratory, Dhantoli, Nagpur – 440 012
E-mail: puripj@rediffmail.com

Article History:
Received:6 January 2011
Accepted:20 January 2011

ABSTRACT
This paper is intended to be a study concerning water pollution with heavy metals in Nagpur City, Maharashtra, India. The levels of the occurrence of heavy metals like cadmium (cd), iron (Fe), zinc (Zn), arsenic (As), mercury (Hg), lead (Pb) and chromium (Cr) were estimated in Futala, Ambazari, Gandhisagar and Gorewada lake, within Nagpur city, for the session January to December 2008. Sampling points were selected on the basis of their importance. The monitoring was made over a period of one year comprising of three seasons; summer, winter and rainy season respectively. The study demon started gradual increase in pollution input of heavy metals in studied lakes. The yearly variation in the concentration of heavy metals had definite upward trends. Present study revealed that dissolved constituents of Fe, Pb, Zn and Cr were above ranges of unpolluted water indicating their contamination throughout the season in cases of Pb, Fe and Zn and occasional for As and Hg. The metals Zn, Fe, Cd, Ni almost remained in natural level while arsenic (As) was always below the detection limit of 0.0001ppm. The Futala, Ambazari and Gandhisagar except Gorewada lake could be identified as probable area of contamination of these metals. The average levels of metals in studied lakes followed the order Zn > Cr > Fe > Cd > Pb > Hg > As.
Keywords: Heavy metals, pollution, Lakes, Water Quality.

INTRODUCTION

Heavy metals are important environmental pollutants and their toxicity is a problem of increasing significance for ecological, evolutionary, and environmental reasons[1]. Heavy metals have played great roles in genesis of present day civilization. In ancient times, the wealth of Emperors and Kings was attributed to the possession of metals like iron, gold, silver copper etc. in different forms. Still today, the dependence of heavy metals has not decreased as these are very commonly used in agriculture, medicine, engineering etc. The magnitude of danger of environmental pollution by heavy metals was probably for first time realized with the Minimata disaster in Japan, where thousand of peoples suffered with mercury poisoning after consuming the fish caught in Minimata Bay. The bay got contaminated with mercury released from vinyl chloride plant between 1953 and 1960[2]. Similarly, it was also reported in Japan in 1955 that cadmium caused itai-itai Byo' disease in human beings, mainly in women over forty. This was due to high level of cadmium in local foodstuffs attributable to irrigation water from soil heaps of an abandoned mine. Minimata raised its ugly head once again, not in Japan this time, but in fishing communities of Amazon rain forest. Heavy metal pollution has been worked out in recent days[3-13]. Thus in view of this widely used practice; it was of interest to undertake further investigation on these lines. The purpose of study is to promoting and coordinating activities in the field of environmental chemistry as well as health related water microbiology and hygiene.

MATERIALS AND METHOD

Physicochemical characteristics (only pH, conductivity and turbidity), of water samples were determined within twenty four hours of the collection of water samples using standard methods[14]. Total trace metals were determined in acidified water samples after pre concentration by atomic absorption spectrophotometric methods. The metals Fe, Pb, Hg, Cu, Zn, and As were estimated using Atomic Absorption Spectrometer (Make - GBC Australia, Model GBC 932). Air-acetylene flame technique was used for all these metals and hydride generator technique was used for arsenic. For dissolved metals, water samples were preserved by adding HNO_3 and filtered through Millipore filtering unit. One liter of the filtered sample was evaporated to dryness and digested with HNO_3,

$HClO_4$ mixture. The digested samples were made up to the volume and dissolved metals were analyzed by AAS. Iron, manganese and zinc were subjected to ten-fold concentration by evaporation. Cadmium, chromium, copper and lead were concentrated by complexing with ammonium pyrrolidine dithiocarbamate (APDC) and subsequently extracting the complex in methyl isobutyl ketone (MIBK). Iron, manganese and zinc in aquatic solution and cadmium, chromium, copper and lead in organic solution, were determined by atomizing respective solutions in Atomic Absorption Spectrometer. The instrument was operated in flame mode using air as oxidant and acetylene as fuel Operation parameters were optimized for maximum response. Background correction was made for lead and cadmium and flame rich in acetylene was used for chromium determination. Water samples were analyzed by both classical and automated instrumental methods as appropriated in standard methods for analysis of water and waste water[14]. All reagents used were of analytical grade and instruments pre-calibrated appropriately prior to measurement. Replicate analyses were carried out for each determination to ascertain reproducibility and quality assurance

RESULTS AND DISCUSSION

Seasonal variations were noted in the physicochemical properties of studied lake water Different properties like pH, EC, Temperature, $HCO3^-$ and conductivity showed maximum values during summer, while minimum values were recorded during autumn season. The observed trend could be attributed to the evaporation of water from studied lake (Gandhisagar, Ambazari, Futala and Gorewada Lake) during summer and subsequent due to precipitation and runoff from catchment area during rainy season[15-16]. High pH values in all studied lakes during summer could be ascribed to increased photosynthetic assimilation of dissolved inorganic carbon by planktons[17]. A similar effect could also be produced by water evaporation through loss of half bound CO_2 and precipitation of mono-carbonate[18]. The alkaline pH and high alkalinity of Futala, Ambazari and Gandhisagar lake water might be due to use of detergents by neighboring population for washing of cloths, vehicles, and utensils. Higher alkalinity in Futala, Ambazari and Gandhisagar indicated the potential susceptibility of these water bodies for eutrophication. Lake water bodies with alkalinity values above 100 mgL^{-1} is considered nutritionally rich [19] and on the basis of this observation most of lakes in Nagpur city could be considered prone to eutrophication problems.

Seasonal variation in different heavy metal concentration in water from Futala, Ambazari, Gandhisagar and Gorewada lake are presented in Table 1-4. Graphical representation of seasonal variation in different heavy metal concentration in water from Futala, Ambazari, Gandhisagar and Gorewada lake are presented in Figure1-4. Figure 5 represents map showing Gandhisagar, Ambazari, Gorewada and Futala lake, Nagpur (MS) India. The concentration of heavy meals in water of studied lakes remained below toxic limits with few exceptions. A remarkable high concentration of (Fe) iron, ranged from 0.022 mgL^{-1} to 0.035 mgL^{-1} , 0.014 mgL^{-1} to 0.031 mgL^{-1} , 0.025 mgL^{-1} to 0.031 mgL^{-1} and 0.012 mgL^{-1} to 0.016 mgL^{-1} in Futala, Gandhisagar, Ambazari and Gorewada lake respectively. The Fe content indicated that this metal was abundant in soil and rocks of catchment area from where the water reaches to these lakes. As regards the effect of season on heavy metals concentration in water of Futala, Ambazari and Gorewada lakes, concentration of metals like Cd, Cr, Fe, Ni, Pb, Zn, Hg were maximum during summer and rainy season while minimum concentrations were observed during autumn season. This trend could be attributed to the evaporation of water from lakes during summer and subsequent dilution due to precipitation and run off from catchment area during rainy season[20]. The variation of level of occurrence of heavy metal in Ambazari, Futala and Gandhisagar lake were found different from each other due to the variation of the solubility of the existing forms of metal in water as well as their availability in the immediate environment. Among metals the level of Zinc ranged from 0.025 mgL^{-1} to 0.0.048 mgL^{-1} , 0.016 mgL^{-1} to 0.041 mgL^{-1} , 0.021 mgL^{-1} to 0.032 mgL^{-1} and 0.012 mgL^{-1} to 0.021 mgL^{-1} in Futala, Gandhisagar, Ambazari and Gorewada lake respectively. Arsenic (As) level was always less than 0.1ppb in Ambazari, Futala, Gorewada and Gandhisagar respectively. The average level of metals (in ppm) followed the similar order Zn > Cr > Fe > Cd > Pb > Hg > As for both Futala and Gandhisagar lake respectively. The ranges of variation in present study revealed that the dissolved constitutes of Pb, Cd, Zn, Cr and Zn was above the ranges of unpolluted water indicating their contamination in water. Cadmium was detected in traces and ranged from 0.010 mgL^{-1} to 0.012 mgL^{-1} , 0.004 mgL^{-1} to 0.008 mgL^{-1} , 0.003 mgL^{-1} to 0.016 mgL^{-1} and 0.001 mgL^{-1} to 0.002 mgL^{-1} in Futala, Gandhisagar, Ambazari and Gorewada lake respectively. Cadmium is a non essential metal that is toxic even when present in very low concentration. The toxic effect of cadmium is exacerbated by the fact that it has an extremely long biological half – life and is therefore retained for long periods of time in organisms after bioaccumulation. Cadmium is a respiratory poison and may contribute to high blood pressure and heart diseases[21]. Cadmium has been found to be toxic to fish and other aquatic organisms. Its effect on man includes kidney damage and serves pain in bones (itai – itai in Japan). The level of lead (Pb) was higher during summer and rainy season as compared to autumn season in all studied lakes. Variations in lead (Pb) level varied from 0.014 mgL^{-1} to 0.026 mgL^{-1}, 0.018 mgL^{-1} to 0.022 mgL^{-1}, 0.025 mgL^{-1} to 0.034 mgL^{-1} and 0.011 mgL^{-1} to 0.021 mgL^{-1} in Futala, Gandhisagar, Ambazari and Gorewada lake respectively. Adverse Chronic effects may occur at 0.5 mgL^{-1} to 1.0 mgL^{-1} (Pb). At levels greater than 0.1 mgL^{-1} possible neurological damage in fetuses and children may possible. The possible source of Pb in studied lakes could be from domestic sewage, immersion of idols of God and Goddess during festival season and effluent discharge from waste disposal sites as well as geology of catchments. Chromium was detected with lower levels in autumn and higher throughout monitoring period during summer and rainy season respectively. The heavy metals concentration in all studied lakes showed distinct temporal and spatial variations. Among metals, concentration of arsenic (As) remained always below the detection level throughout study period in entire stretch except Futala and Ambazari lake. Thus it could be presumed that levels of (As) arsenic in Gorewada lake remained almost in natural level and there was probably no anthropogenic input in Gorewada lake for its enrichment. Since pH of studied lake water lies in the range of neutral to alkaline the levels of studied metals could not rise so much as there are natural mechanism to remove these metals from aqueous solution and prevent from enrichment. A high degree of yearly variation was observed in zinc concentration. Its yearly variation showed an upward trend. In natural water system Zn remains as either hydroxide or carbonate form with having almost same solubility which is higher than solubility of existing forms of other metals. This could be the reason for comparatively higher values of Zn in studied lake water. The average level of metals followed the order Zn > Cr > Fe > Cd > Pb > Hg > As for both Futala and Gorewada lake respectively. Higher values of metals in all studied lakes are due to washing activities, recreational activities, immersion of idols of God & Goddess during and after festival seasons, vehicle washing, farming (agricultural) activities, weathering of minerals and soils, atmospheric deposition, storm water run off resulting from rainfall, and (poor) sewage. Thus, water system with enriched toxic metals can serve as reservoirs and may becomes a potential source to supply toxic metals in the environment. chromium content in studied lakes ranges from 0.028 mgL^{-1} to 0.042 mgL^{-1}, 0.028 mgL^{-1} to 0.036 mgL^{-1}, 0.014 mgL^{-1} to 0.028 mgL^{-1} and 0.016 mgL^{-1} to 0.018 mgL^{-1} in Futala, Gandhisagar, Ambazari and Gorewada lake respectively. Chromium ingestion over admissible limits leads to allergic phenomena and lung cancer. Mercury is considered to be the most toxic metal. In organic form it enters the human through fish. Fishes being one of main aquatic organism in food chain may often accumulate large amount of certain metals[22]. Highly significant difference was noticed in case of mercury (Hg) in water samples collected from Futala, Ambazari and Gandhisagar lake. The concentration of mercury in water varied from 0.005 mgL^{-1} to 0.018 mgL^{-1}, 0.008 mgL^{-1} to 0.018 mgL^{-1}, 0.010 mgL^{-1} to 0.021 mgL^{-1} and 0.001 mgL^{-1} to 0.003 mgL^{-1} in Futala, Gandhisagar, Ambazari and Gorewada lake respectively. The continuous increase in heavy metal contamination in studied lake is a cause of concern as these metals have ability to bioaccumulate in tissues of various biota's and may also affect distribution and density of benthic organisms as well as composition and diversity of faunal communities. Since pH and temperature affects solubility and toxicity of metals in aquatic ecosystem, this pH and temperature ranges were also used to access the metal toxicities in studied lakes. Metals such as Cd, Pb and Zn are most likely to have increased detrimental environmental effects as a result of lowered pH..

Table-1: Heavy metal content (ppm) during different seasons of the year at Futala lake.

Season	Heavy Metals (mgL^{-1})						
	Zn	Cr	Fe	Cd	Pb	As	Hg
Summer	0.048	0.042	0.035	0.012	0.026	BDL	0.018
Winter	0.025	0.039	0.022	0.010	0.014	BDL	0.005
Rainy	0.036	0.028	0.024	0.011	0.021	BDL	0.016

BDL :Below Detectable Limit

Table-2: Heavy metal content (ppm) during different seasons of the year at Gandhisagar lake.

Season	Heavy Metals (mgL^{-1})						
	Zn	Cr	Fe	Cd	Pb	As	Hg
Summer	0.041	0.036	0.031	0.008	0.022	BDL	0.012

Winter	0.018	0.028	0.014	0.004	0.018	BDL	0.008
Rainy	0.016	0.030	0.018	0.006	0.020	BDL	0.018

BDL :Below Detectable Limit

Table-3: Heavy metal content (ppm) during different seasons of the year at Ambazari lake.

Season	Heavy Metals (mgL^{-1})						
	Zn	Cr	Fe	Cd	Pb	As	Hg
Summer	0.032	0.028	0.025	0.005	0.031	BDL	0.016
Winter	0.025	0.016	0.029	0.003	0.025	BDL	0.010
Rainy	0.021	0.014	0.031	0.016	0.034	BDL	0.021

BDL :Below Detectable Limit

Table-4: Heavy metal content (ppm) during different seasons of the year at Gorewada lake.

Season	Heavy Metals (mgL^{-1})						
	Zn	Cr	Fe	Cd	Pb	As	Hg
Summer	0.018	0.020	0.011	0.002	0.016	BDL	0.001
Winter	0.012	0.018	0.012	0.001	0.014	BDL	0.001
Rainy	0.020	0.013	0.001	0.010	0.002	BDL	0.003

BDL :Below Detectable Limit

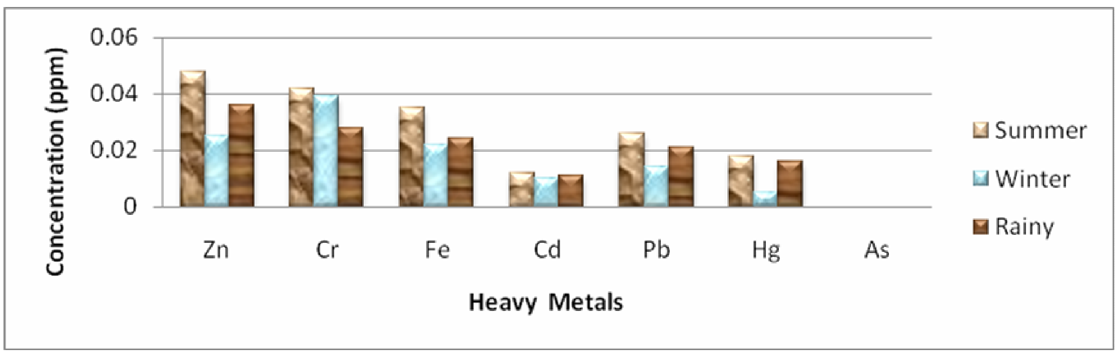

Fig-1: Heavy metal content (ppm) during different seasons of the year at Futala lake.

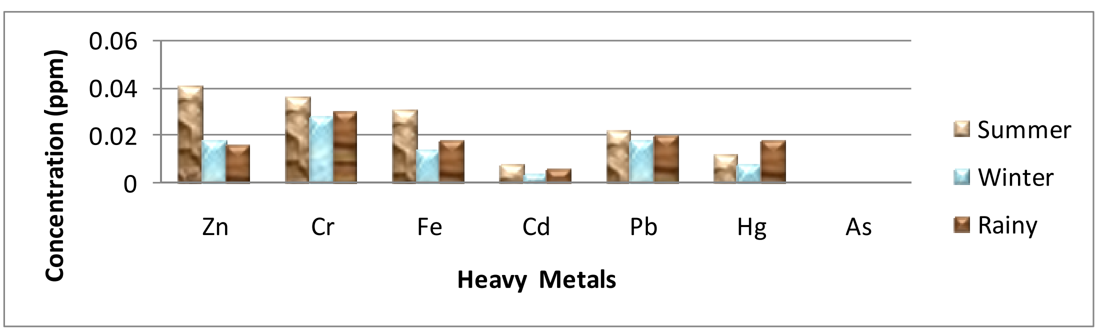

Fig.-2: Heavy metal content (ppm) during different seasons of the year at Gandhisagar lake.

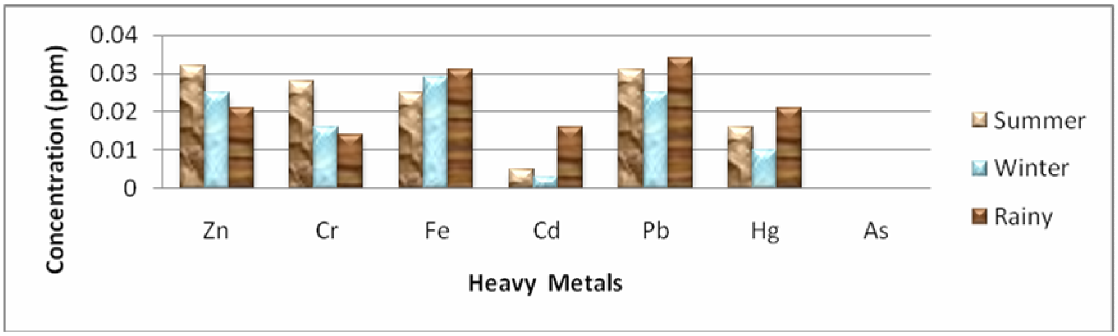

Fig.-3: Heavy metal content (ppm) during different seasons of the year at Ambazari lake.

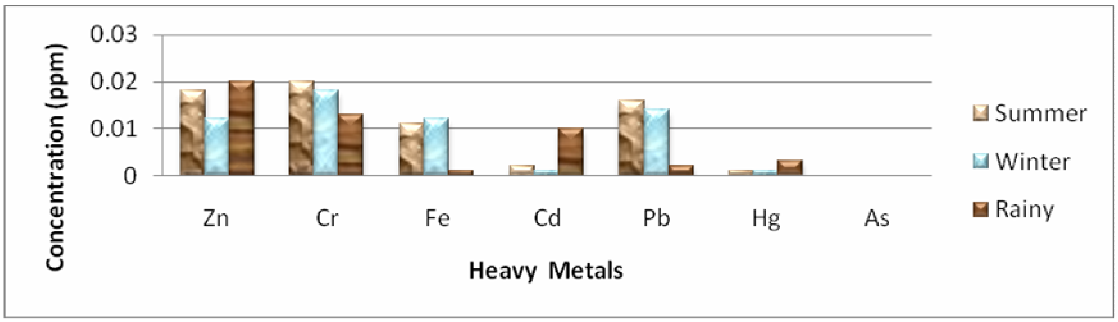

Fig.-4: Heavy metal content (ppm) during different seasons of the year at Gorewada lake.

CONCLUSION

The heavy metal concentration in studied lake showed distinct temporal and spatial variations. There was significant seasonal variation in metal concentration within the study period. The dry season registered elevated levels of metals as compared to wet season. Dilution effect of rainy season due to storm run off into receiving lakes and excessive evaporation of surface water with its attendant pre-concentration of most of metals may be responsible for observed trend. The results of study have indicated gross pollution of lakes especially regards heavy metals. This poses a healthy risk to several communities in catchment who rely on these lakes primarily for their domestic sources without treatment. An elevated level of heavy metals in water is a good indication of man – induced pollution as a result of (poor) sewage, domestic waste and immersion of idols of God and Goddess during and after festival season into studied lakes. There were definite upward yearly trends in the concentration of chromium, iron, lead and zinc in studied lakes which indicated increased input of their pollution load. The levels of mercury (Hg) and arsenic (As) in studied lake water were comparatively lower. The average level of metals followed the order Zn > Cr > Fe > Cd > Pb > Hg > As and for all studied lakes. Through some of detected heavy metals are beneficial for human and plants up to a certain limit; it may be harmful beyond that. Adoption of adequate measures to remove heavy metals load from industrial waste water, prevention of immersion of idols of God and Goddess along with fruits, flowers and worship materials along with washing activities are suggested to avoid further deterioration of lake water quality.

ACKNOWLEDGMENTS

The authors hereby acknowledge the kind and wholehearted support of the Dr. S. B. Gholse Director, LIT, RTM, Nagpur University, Nagpur.

REFERENCE

1. Nagajyoti, P.C., Dinakar, N., Prasad, T.N.V.K.V., Journal of Applied Sciences Research, **4(1)** (2008) 110.
2. Friedman, M., Environ. Sci. Technol**.**, **6** **(5)** (1972) 457.
3. Akeson, M. and D. Munns, Journal Plant Nutri., **13** (1990) 467.
4. Anderson, A. and K. O. Nilsson, Sewish Jounal Agricult. Res., **6** (1976) 15.
5. Antonovics, J., A. D. Bradshw and B.G. Turner : Adv. Ecol. Res., **7** (1975) 1.

6. Asami Teuro: Sci. Res. Fac. Agric,. Iberaki Univ ., **23** (1975) 43.
7. Azad, A.S., B.R. Arora, B. Singh and G.S. Sekhon: Ind. J. Ecol., **II (1)** (1984) 1.
8. Borovik, A.S., CRC Press Boca Raton. Florida**, 3-5** (1990).
9. Bowen, J. E. : Plant Physiol, **44** (1973) 255.
10. Dutta, I. and Mookerjee, A., Indian J. Environ. Health, **22(3)** (1980) 220.
11. Fytianos, K., V. Samanidou and T. Agelidis, Ambia **15 (1**) (1986) 42.
12. Mc. Calla, T.M., J.R. Perterson and C.I., Lue ; Ed. Elliot, L.F. and F.J. Stevensn, Sashngton, **28-36** (1977).
13. Vander Werff, M. and J. P. Margaret : Chemosphere**. 11(8**). (1982).
14. APHA; Standards Methods for the examination of water and waste water, 18th edition, (1998).
15. Wiklander, L. and Kantol Vahtras : Geoderma **19 (2)** (1977) 123.
16. Radhika, C. G. Mini, J., & Gangaderr, T.: Pollution Research, **23,** (2004) 49.
17. King, D.L., Journal for the Water Pollution Control Federation , **42**(1970) 2035.
18. Khan, M.A. G., & Choudhary, S.H., Tropical Ecology, **35**, (1994) 35.
19. Patil, P.R., Chaudhari, D.N. & Kinage, M.S. Environemental Ecology, **22**, (2004) 65.
20. Bhatt, L.R. Lacoul, P., Lekhak, H.D., & Jha, P.K. : Pollution Research, **18** (1999) 353.
21. Friberg, L. and C. J. Elinder; Health and Diseases, **18** (1988) 559.
22. Purandara, B.K., Vararajan, N. and Jayashree K. Poll., Res, **22 (2)** (2003) 189.

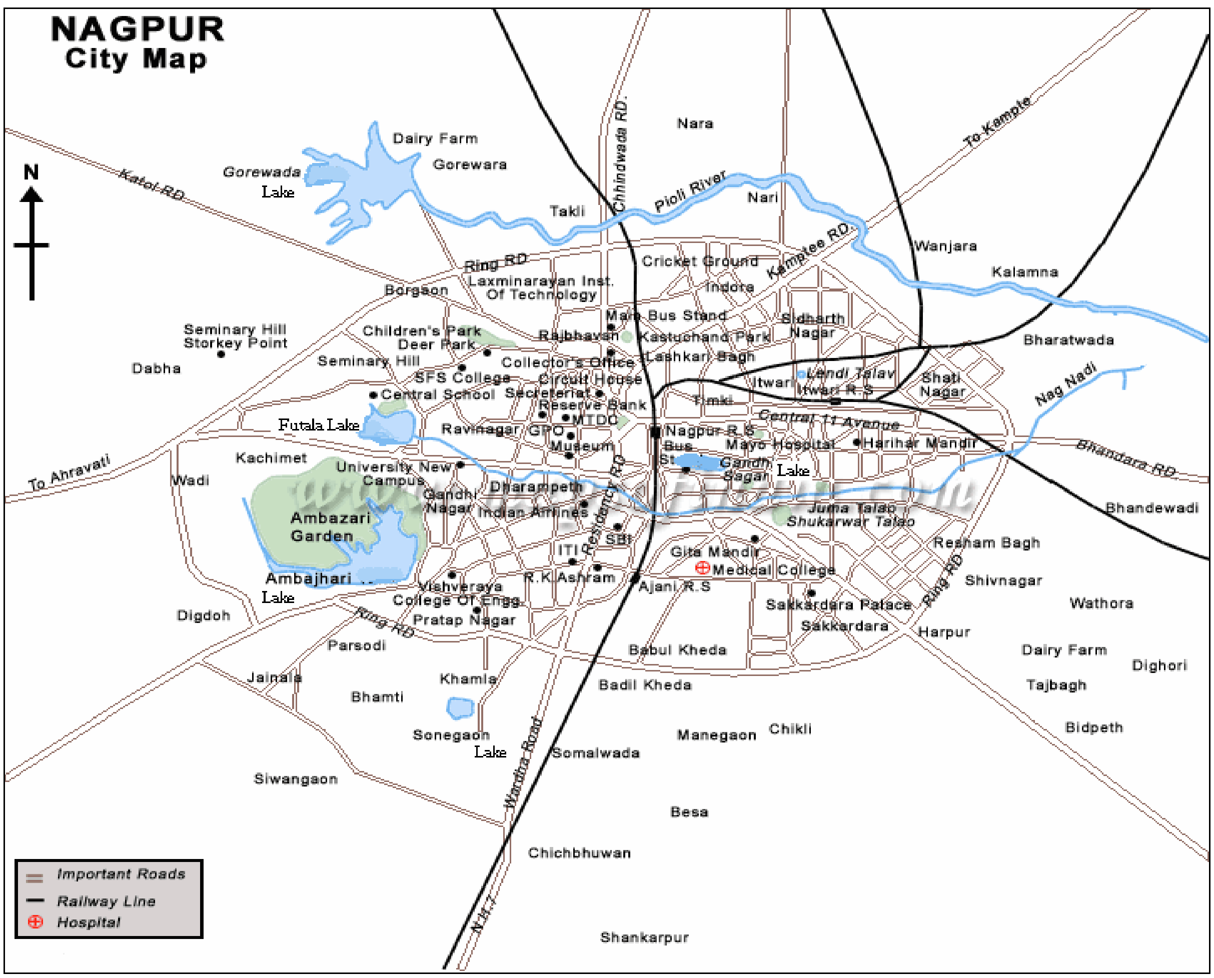

Fig. -5: Map showing Gandhisagar, Ambazari, Gorewada and Futala Lake, Nagpur (MS) India.

[IJCEPR-142/2011]