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Naher-E-Ambari – A Case Study: Rebirth and Recommendation for Medivial Water Supply System (Part-II)

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***Abstract*: This paper present an ancient water management system (Nahar-E-Ambari) which was one of the pure and preferable sources of water in Aurangabad city. Naher-E- Ambari is built by Malik Ambar in 1617 A.D., which was designed for the population of 50000. From the high land across the city from north, east and south wherever the circumstances allowed the engineers of the period, brought down the Naher in Aurangabad city. Thus the city of Aurangabad was having number of Nahers of pure minerals subterranean drinking water.**

The inhabitances of Aurangabad were being benefitted by this water supply system since 300 years regularly without any tax. In over paper, the technical detail of Naher system is discussed in depth. It is world 2nd number water management system based on syphonic action in working condition, but today, with the age, the Naher structure is broken, ruptured and at some places destroyed. In this report we have studied and analyzed some of the parameters such as mapping of aqueduct and manholes by GPS system and water quality standards (physical, chemical and biological) and recommended certain remedial points like, renewal of Nahers, sedimentation tank, aeration and replacement of old water carriage system with a new one, also various repairs to certain structures for improvement of water quality standards. Thus reclamation and appropriate utilization of available water source in Aurangabad city for public sector like drinking, gardening, street washing, and public toilets.

Keywords: Nahar-E-Ambari, Water Supply System.

I. Introduction

In the history of Aurangabad, Malik amber in 1617 A.D. introduced a remarkable and efficient system of water supply. Aurangabad city always faced scarcity of water and there were no major sources of water in the nearby vicinity. Owing to hard rock and dry land it was very difficult to construct the pillars to supply water to the town. So this was the great feat of medieval engineering achievement. Malik Amber in 1617 A.D. studied subterranean water table of mountainous elevated valleys in north of Aurangabad. He practically manipulated and procured a stable perennial water supply for a population of 50000 by constructing his unique wonderful aqueduct by the name Khair-E-Jari. The old water supply system is the reminiscent of medieval period. At the entrance of town, there are numerous buildings, palaces, tombs, mosque, fortifications and rectangular or round pillars erected on the roadsides. These high pillars are called “distribution chambers” which clearly indicate the medieval system of supplying water.

The city of Aurangabad had number of Nahers of pure mineral subterranean drinking water. This practice of construction of such aqueducts continued from the period of Malik Ambar (1617) up to the time of Aurangzeb and Asif Jan (1803) for a period of about two centuries. On the high lands around the city from north, east and south. Rulers like Malik amber, Shah Mehmood and Shah Ali are founders, designers and planners of these famous, wonderful and useful aqueduct system of Aurangabad. During the long period of three and half centuries this unique, god gifted old water supply system prevailed and lasted up till now, the inhabitants of Aurangabad were being benefited by this water supply system since three hundred years regularly without any tax.

During the military activities, Malik Ambar discovered the Kham river valley and its large natural basin of about 150 sq. Miles over head of a well-planned and layout city. Malik amber has designed the construction of the aqueduct in a very simple appearance and natural way underneath the river bed of Sawangi and Kham River which has got number of man holes overhead called Abgir Nali Upto Gaimukh. An earthen dam was constructed on the river Kham on the north of Aurangabad city.

II. Literature

Vicinity-Shaikh Afreen et.al. [1], Study of aquatic protozoan in neher-e-Ambari in Aurangabad. International science journals 2014. The present research work covers systematic study of morphology and prevalence of free living protozoan from fresh water bodies of neher-e-ambary in Aurangabad region of Maharashtra (India). During this study total number of 15 species have been recorded i.e. 10 species of ciliates, 5 species flagellates and some actinopods, rhizopods have been reported. Most of the ciliates and flagellate species which are obtained directly from water samples or from various type of culture viz; boiled egg infusion, yeast infusion, phaseala radiates, lens culinary (lentil) infusion, rice infusion, wheat infusion, hay infusion,etc.

Pradeep Purandaree [2], Water governance and droughts in Marathwada- 2012. An attempt has been made here to review the 2012 drought in the Marathwada region of Maharashtra based on various issues as reported in the Aurangabad edition of the state’s newspapers.

Pratik V. Mane [3], engineering aspects of neher-e-Ambari and its necessity in Aurangabad (Maharashtra).study and analyze the hydraulic characteristics of Nahar-e-Ambari constructed in 1968, study the spread of the Nahar-e-Ambari aqueduct system over the Aurangabad city, to analyze a scope / feasibility regarding utility of the aqueduct in the existing water supply system of Aurangabad, Nahar-e-Ambari water course, construction of aqueduct, siphon system aqueduct, air towers, pioneer of a unique everlasting aqueduct of the world, underground water through aqueduct, advantages.

Dr. P.A.Sadgir and Dr. U.J.Kahalekar.[4], dying wisdom of medieval water management of Aurangabad city. Planning designing and construction of old water supply system the old system of water supply was dependent on the canals. If we try to find out the origin of these canals outside the town we will find only huge land fields. At the origin there is neither any construction work nor deposit of water. As the origin of these canals are either in the lap of mountain or in the vicinity of river.

Dr.Shaikh Ramzan [5], 400 years under ground living Aqueducts. This book written by Dr. Sheikh Ramzan in 2010 and his study of all naher exist in Aurangabad and camplit his Ph.D. on this subject. His conduct following points on this book, Nahar-e-Ambari aqueduct, Gaimukh, Nahar-e-panchakki, different types of aqueduct, manholes on Nahars, earthen pipelines in tunnels, siphon systems, air towers, junctions of towers, photos, maps, sketches.

Dr.Dilip B.Boralkar e.al [6] submitted to district planning & development council under the aegis of district magistrate & collector Aurangabad 2012.project proposal on bioremediation of sewage disposal in the Kham River at Aurangabad (Maharashtra) Aurangabad is not blessed with unlimited water resources. The city has crossed population total of one million. There is tremendous pressure on limited drinking water availability and its distribution in the city. The city is generating sewage at about 100 million liters per day (MLD). Untreated sewage disposal is of concern as it is cause of water pollution.

W. James Marold, et.al [7] water storage, transport, and distribution-aqueducts, tunnels, canals, pipelines, siphons, and water distribution. Tunnels: lining, grouting, rock bolts, blasting, boring, And canals: lining, routing, control structures, siphons: inverted, head recovery, pump discharge, pipe materials, hydraulics, equalization storage, carrying capacity, cross connections.

Evan James Dempsey [8], the aqueducts of ancient Rome February 2009. This thesis will examine the eleven main aqueducts that fed the city of Rome; how they were made, what they were made of, when and how they were repaired, the tools that were used to make them, the skills needed to make them and how the prevailing political climate that existed at the time influenced the construction of each aqueduct. As far as possible, the distribution of water from each aqueduct will be examined, but this aspect may be considered an insoluble problem.

Jean Deloche [9], water supply systems of the senji (gingee) fortinsouth India (16-18th century), Indian journal of history of science 2012. The domestic water supply systems of the fort of senji in the Tamil country employed rain water storage ponds and catchment tanks for the supply of the urban settlement, thus exploiting the hydrological environment to the maximum advantage by using the available technologies. In the fort, two water systems which correspond to two periods of great hydraulic works were constructed (deloche 2005, pp. 189-200).

S. Krishna Kumar et.al. [10], Hydro-geochemistry and application of water quality index (WQI) for groundwater quality assessment, Anna nagar, part of Chennai city, Tamilnadu, India. Published with open access at springerlink.com 2014. Ground water contamination in urban environment is a major issue and is complicated by large number of potential source of contamination (jayaprakash et al. 2008). India has wide spectral variations of meteorological, materials and methods, chemical and physical parameters, correlation matrix.

R. T. Sniegocki and J. E. Reed [11], In 1953 the Grand Prairie region of Arkansas was -elected for an investigation of the principles or artificially recharger, Ground-water reservoirs in alluvial deposits through wells. This area in the coastal plain of east-central Arkansas provided a large natural laboratory in which studies of general interest could be made. The U.S. army, corps of engineers, and the University of Arkansas have actively participated with the U.S. geological survey in these studies.

Hubert Chanson [12], The roman engineering heritage encompasses a number of magnificent structures including bridges, roads, dams and aqueducts, with many still standing. Among these, the aqueducts constitute a fine example of water resource engineering and many aqueduct sections are still in use, in Tunisia, Spain and France for example. Surprisingly, relatively little is known on their engineering design nor the hydraulic knowledge of roman engineers (Hodge 1992, Fabre et al. 2000).

W. James Marold et.al. [13], These structures may be combined in any manner to carry water for long distances to holding reservoirs or water treatment plants for distribution to the water consumers. The largest aqueduct in the world supplies southern California with nearly 44 m^3 s^{-1} of water carried in open concrete-lined canals from the Colorado River. The aqueducts used to supply water to New York City are tunnels and vary from 53 to 148 km in length. Both systems withdraw water from storage reservoirs formed by large.

Kollipara Parvathi Manjusha, et.al [14], An aqueduct structure is a complex structure as compared to bridge, as it takes canal water across stream and canal traffic over the trough. The water tightness and free expansions - contractions of trough, canal water load as well as traffic load on the trough involves complex load combinations, for which the superstructure and substructure of it is required to be planned and designed.

Yawar Mushtaqraina e.al [15], Aqueduct is the cross drainage arrangement which make the route of water from one side of drain to the other. Most of the rajouri town is hilly and semi-hilly belt. At rajouri about 9000 hectares areas of land remain deprived of irrigation facilities. The main aim of the paper is to present the hydraulic design of aqueduct proposed over Darhali River in rajouri town and explain as to why aqueduct was required in this area. To assist the growth of crops in areas adjoining to Darhali River construction of

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aqueduct from left bank to right bank of river was projected. Aqueduct of 6 x 9.5m span was proposed to be constructed.

Anand G. Pagare, Ajay Sawant, Kishor Lokhande e.al [16], This paper present on the ancient water management system (Nahar-E-Ambari) was one of the pure and preferable sources of water in Aurangabad city. And it's built by Malik Ambar in 1617 A.D. it is design for population of 7 Lakh. On the high land around the city from north, east and south wherever the circumstances allowed the engineers of the period brought down Nahar in Aurangabad city. In city of Aurangabad was having number of Nahars of pure minerals subterranean drinking water.

III. Approach Methodology

A. *Mapping*

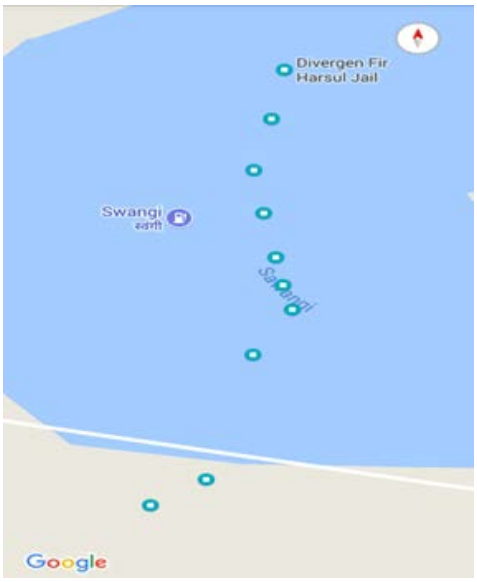

Fig. 1. Image-1: Screenshot of mapping (GPS)

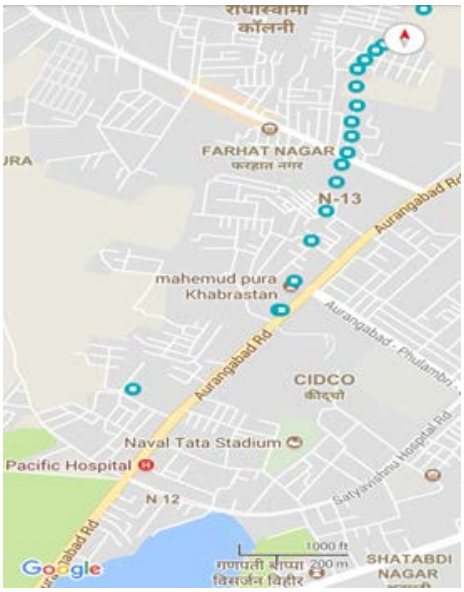

Fig. 2. Image-2: Screenshot of mapping (GPS)

Field survey was conducted in this project to locate water towers with the help of GPS: Then with the use of quantum GIS software, the map of positions of water towers & flow of water in aqueduct from start point (Sawangi Lake, harsool) to end point (Gaimukh, opp. Taj hotel) were located. Use of GPS and Google map provide the location in x and y co-ordinates. Fixed distances and points were located step by step. There were 100 water and air towers from which 86 were located with the help of GPS. Following are the images of data collected and prepared.

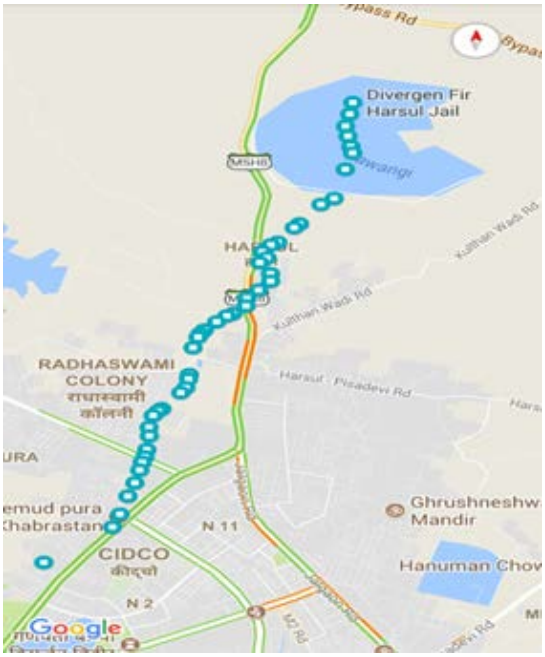

Fig. 3. Image-3: Screenshot of mapping (GPS)

Fig. 4(a). Water /Air towers

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Fig. 4(b). Water /Air towers

TABLE I
WATER TOWER LOCATION OF CO-ORDINATES

S. No.	X Co-ordinate	Y Co-ordinate
1	19.908826	75.3342950
2	19.909188	75.334555
3	19.909596	75.334514
4	19.910397	75.334573
5	19.910904	75.334668
6	19.911782	75.334757
7	19.906239	75.341424
8	19.908962	75.345301
9	19.908956	75.345716
10	19.911317	75.346157
11	19.912329	75.346543
12	19.913306	75.34681
13	19.913905	75.346945
14	19.914306	75.347094
15	19.914866	75.347199
16	19.915358	75.347196
17	19.915905	75.347334
18	19.916555	75.347308
19	19.917142	75.347335
20	19.917455	75.347529
21	19.917785	75.3481
22	19.917971	75.34795
23	19.917971	75.3148017
24	19.91916	75.349085
25	19.919274	75.34922
26	19.919574	75.349372
27	19.919957	75.349435
28	19.920237	75.349515
29	19.920358	75.349591
30	19.920577	75.349554
31	19.920748	75.349424
32	19.922622	75.349748
33	19.922785	75.349751
34	19.923056	75.349896
35	19.923424	75.350023
36	19.923691	75.350152
37	19.923964	75.35371
38	19.924002	75.350341
39	19.923908	75.350467
40	19.924282	75.350678
41	19.924468	75.350965
42	19.924595	75.351071
43	19.9249	75.351455
44	19.924853	75.351523
45	19.925045	75.351646
46	19.251	75.351734
47	19.925214	75.351985
48	19.925315	75.352363
49	19.925369	75.352593
50	19.925501	75.352698
51	19.925818	75.352736
52	19.92611	75.352721
53	19.926416	75.35277
54	19.926532	75.35291
55	19.926646	75.353089
56	19.927027	75.35343
57	19.927234	75.353792
58	19.927467	75.353844
59	19.927708	75.354111
60	19.927934	75.35408
61	19.928273	75.354097
62	19.92884	75.353586
63	19.929115	75.353478
64	19.929473	75.353484
65	19.929483	75.353883
66	19.92994	75.353608
67	19.93019	75.353832
68	19.930462	75.354103
69	19.93066	75.354492
70	19.931375	75.355223
71	19.93778	75.355414
72	19.932071	75.355711
73	19.933556	75.356917
74	19.934021	75.357668
75	19.936242	75.358279
76	19.93705	75.358804
77	19.937482	75.358674
78	19.937973	75.358571
79	19.938756	75.358399
80	19.939519	75.358257
81	19.940432	75.358487
82	19.941307	75.358652

B. Water Quality Parameters

Water quality parameters were studied at the start point and end point of Naher-E-Ambari in two seasons. Details are as below.

Note:

1) Sample 1 - Lake Water(Sawangi), Dt.1st Feb 2018, Time 8.30AM
2) Sample 2 – Gayemukh, Dt.1st Feb 2018, Time 9.00AM
3) IS 10500:2012 Indian Standard Drinking Water, Vol.2

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TABLE II
WATER TESTING-1 (1ST TESTING (06-02-2018))

S. No.	Parameters	Limit (IS 10500: 2012)	Sample-1	Sample-2	Unit
1	Color	5	5	5	Hazen
2	Odor	Agreeable	Agreeable	Agreeable	-
3	Temperatu-re	22-30	23.7	24.2	^{0} C
4	Ph.	6.50-8.50	7.9	8.2	-
5	Turbidity	5	8	5	NTU
6	BOD	3-5	16	2.4	Ppm
7	COD	5	74	14	Ppm
8	Carbonate		1.99	3.82	Mg/L
	Bicarbonate		265.97	256.11	Mg/L
9	Alkalinity	200-600	268	260	Mg/L
10	Total Hardness	200-600	540	440	Mg/L
11	Acidity	1.5	ND	ND	Ppm
12	Residual Free Chlorine	0.2 – 1.0	ND	ND	Mg/L

Note:
1) Sample 1 - Lake Water(Sawangi), Dt.1st April 2018, Time 8.30AM
2) Sample 2 –Gaimukh, Dt.1st April 2018, Time 9.00AM
3) IS 10500:2012 Indian Standard Drinking Water, Vol.2

TABLE II
WATER TESTING-2 (2ND TESTING (09-04-2018))

S. No.	Parameters	Limit (IS 10500: 2012)	Sample 1	Sample2	Unit
1	Color	5	5	5	Hazen
2	Odor	Agreeable	Agreeable	Agreeable	-
3	Temperature	22-30	24	28	^{0} C
4	Ph.	6.50-8.50	8	8.2	-
5	Turbidity	5	9	7	NTU
6	BOD	3-5	19	3.7	Ppm
7	COD	5	75	18	Ppm
8	Carbonate		2.44	1.22	Mg/L
	Bicarbonate		270.8	245.8	Mg/L
9	Alkalinity	200-600	272	265	Mg/L
10	Total Hardness	200-600	558	560	Mg/L
11	Acidity	1.5	ND	ND	Ppm
12	Residual Free Chlorine	0.2 – 1.0	ND	ND	Mg/L

After the collection of first sample the results are shown in Table-1, according to which this water is drinkable. Second testing was scheduled on 3rd April 2018. The Average of these two testing results gives more accurate values of water quality parameters. According to these results analysis & compare with IS Codes and recommend suitable filtration process or method for these Naher- E-Ambari. Simultaneously study QGIS and collect data required for this application to prepare map of Nahar. In Google Earth available coordinates are in different units and QGIS Requires coordinates in degree so all 86 coordinates are converted in degree and after conversion put those values in QGIS for preparing map.

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IV. CONCLUSION AND RECOMMENDATION

During Nahar survey, we realized the following points which are responsible for Nahar demolition.

1. The origin of the Naher is the Harsul Savangi Lake that Excavate the sand and hence the underground aqueduct in the middle of the pond has been damaged.
2. The farmer lift the water from the Neher, which are situated at some distance of a pond, and for that they have broken the water towers.
3. This underground aqueduct has been found in nearby colonies at Jalgaon Road and many of the houses in that colony have been built on top of the aqueduct and water tower has also been damaged and some open water tower are used as dustbin.
4. The Aqueduct has gone through the old village of Harsul and there are demolisation of water towers by local people.
5. At the Harsul Ekata nagar, the people are using electric motor/ Submersible motor are used to lift the water from Naher and founded the water tower damaged there too.
6. Some water tower has been found provision of iron grills in some places, but they are missing in some places.

Considering the above data, the solution below requires reason.

1. Stop the illegal excavation of sand and repair the underground aqueduct.
2. To increase the water holding capacity of the pond by removing the silt and provide the stone lining along the pond outer boundary.

3. Stop illegal water lifting at agricultural and residential areas.
4. Place the canal screening chamber near the start location so that the solids particles cannot enter it.
5. After repairing the water tower and finishing exhausted complete tower, set up an iron grille on the top of tower to stop unwanted excess.
6. Rebuild the water inspection tank / sedimentation tank near Harisiddhi mata temple.
7. Provide the Disinfection Chamber and aeration chamber at existing water purification project.
8. Provide fountain aeration near the road junction (Near Taj Hotel). It gives attractive view as well as aeration can be done.

If the above remedy is planned, then there will be enough water in the Nahar and it will be used for some areas of Aurangabad and it can be used to save you historical heritage.

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