Evaluation of Water Quality with Waterborne Diseases for Assessing Pilgrimage Impact along River Indrayani, Pune (India)

[1]Marale S. M.[*], [2]Mahajan D. M., [3]Gavali R., S. [4]Rao K. R.

[1]Department of Environmental Sciences, University of Pune, India

[2]Department of Botany, Waghire College, University of Pune, India

[3]School of Earth Sciences, University of Solapur, India

[4]College of Military Engineering, Khadaki, Pune, India

[*] maralesanjay@gmail.com

***Abstract*- Water pollution due to residents and pilgrims causing waterborne health related diseases especially AGI (Acute Gastro Enteritis) amongst local population. The river water monitoring was carried and a questioner based survey was used to estimate water-borne and enteric disease incidence amongst the local residents and floating population consisting of pilgrims, tourists etc. 1.75% of local population suffered AGI at Alandi and 1.53% local population suffered due to AGI at Dehu. Various health disorders such as skin itching, ear pain, throat irritation, nausea etc were reported in the pilgrims. Multi-criteria approach is used to evolve composite quality index (CQI). The impact due to occurrence of AGI for various factors calculated using a parameter called as Odd Ratio (OR). It is observed that the odd ratio (OR) has decreased by 28% and 32% in Dehu and by 49% and 63% at Alandi during pilgrimage periods of Ashadi and Kartiki respectively, thereby indicating increased trend of number of people suffering from AGI due to pilgrim activities during pilgrimage period in comparison to non pilgrimage period.**

Keywords*- *Sewage pollution; Pilgrimage activities; Composite Quality Index; Odd Ratio; Skin diseases; Solid Waste

I. INTRODUCTION

Much of the world's population remains without access to potable water supplies and adequate methods to dispose of human fecal waste [1] . Population growth and anthropogenic activities along the banks of river is causing pollution of water, air and soil and are contributing to the increasing number of human diseases worldwide. As per WHO estimates 1.1 billion people lack access to an improved drinking water supply; many more drink water that is grossly contaminated.

There are 4 billion cases of AGI (Acute Gastro Intestinal disease) worldwide occurring annually, of which 88% is attributable to unsafe water, and inadequate sanitation and hygiene. 1.8 million People die every year from AGI related diseases out of which vast majority are children under five years of age. It is estimated that 94% of diarrhoeal cases are preventable through interventions such as increasing the availability of clean water, improved sanitation and hygiene [2]. Water-related diseases caused by inadequate water supply and sanitation impose an especially large health burden in Africa, Asia, and the Pacific region. In India alone, over 700,000 children under 5 die annually from diarrhea [3].

Several possible causes of outbreaks and endemic transmission associated with surface water were reported worldwide [4], [5]. A number of chemicals present in food substances such as monosodium glutamate, organic mercury, and antimony and copper can also induce gastrointestinal symptoms [6]. Disease transmission is also affected by host characteristics and behavior including immunity, nutritional status, health status, age, sex, personal hygiene, food hygiene [7] etc. Although the entire solution may lie in a multi-sectoral approach and achievements including overall socio-economic development, provision of safe and adequate water and sanitary facilities in the built up areas on river banks and effective wastewater management seems among major issues of immediate concern for reducing the burden of such diseases and consequent impairments [8].

Environment to person transmission of AGI is often associated with sources of external contamination due to various issues on the population under study [9]. Model based understanding the patterns of infectious disease and developing appropriate implementable treatment requires acquiring knowledge on biological, physical, and social sciences along with the ability to integrate this information into an effective response [10]. The identification of pollution sources is required for the protection of water resources, and for the necessary pollution control [11]. In developing countries, treatment of water and wastes is often nonexistent or grossly inadequate and until sanitation is improved it will be impossible to impact greatly on the level of waterborne disease [6].

In less developed countries, poor nutritional status and poverty exacerbate morbidity and mortality with excreta related diseases. The behavior modifications as well as technical sanitation solutions are necessary to reduce the transmission of excreta-related disease [7]. A strong correlation was found between AGI diseases, faecal coliform contamination in drinking water and other water quality parameters such as BOD, TSS, DO and TVC for the study area. A questionnaire carried out for the local people in the

DOI 10.5963/IJEP0201002

two locations of Dehu and Alandi in the study area revealed that diarrheal diseases were the most common self-reported disease. The implementation of locally appropriate point-of-use disinfection and safe household storage practices in developing countries is an urgent need to ensure a safe, reliable year- round supply in areas where clean water is not available [12].

People and pilgrims bathing in polluted waters; suffer more from gastro-intestinal diseases then others [13]. As per 2001 Census only 36.4% of the total populations have latrines within/attached to their houses. However in rural areas, only 21.9 percent of population has latrines within/attached to their homes. As on November 2007 sanitation coverage in the country has reached to 49% because of total sanitation campaign programme [14]. Increased water availability and quantity, associated with improved hygiene, may reduce fecal contamination of the hands. Proper cleaning of utensils, food and home environments is also likely to reduce transmission of fecal matter. All the major infectious agents of diarrhea are shed by infected persons via the faeces, and therefore hygienic disposal of human excreta plays a role in controlling them. Use of toilets by all members of the community should reduce fecal contamination [1].

The Hindu pilgrimage has gone through an unprecedented expansion with the modernization of transport infrastructure, the modification of the conditions of access to the site and the introduction of new modes of management of temple space by the government of India. The Pilgrimage to Dehu and Alandi located along River Indrayani in Pune district of Maharashtra, in the study area attracts on an average of 10,000 people to 20,000 people daily and this reaches to 4 to 4.5 lacs during pilgrim period of *Ashadhi*,(June) and *Kartiki* (November) *Ekadashi*. Pilgrims and devotees produce most of the environmental degradation in these pilgrimage areas.

The present paper deals with the issues on deterioration of water quality due to the current practices of pilgrims and local population causing environmental degradation of the River basin, waterborne diseases, and associated health hazards amongst the local population and pilgrims using regression models that relates the composite water quality index (CQI) with health parameter called as odd ratio [4] (OR) associated with various factors in the pilgrimage towns of Alandi and Dehu located in the study area along the banks of river Indrayani.

II. THE STUDY AREA

The River Indrayani, a tributary of River Krishna has its source in the Maval Taluka of Pune District of Maharashtra state. It originates on the crest of the Sahyadris hills of Western GhatsRiver Indrayani carries both industrial and urban effluent. The River does not flow for at least seven to eight months. The river water is so polluted that it is considered as a danger to the health of inhabitants and millions of pilgrims visiting the pilgrimage towns of Dehu and Alandi located on its banks. Dehu is located at 18º43’N73º46’E. It has an average elevation of 594 meters (1948 feet). As of 2001 India census, Dehu had a population of 5340. Alandi is located at 18º 40’37.42”N 73 º 53’47.76’’E and lies 25km east of Pune city. It has an average elevation of 577metres (1893b feet). As of 2001 census Alandi had a population of 17,561.

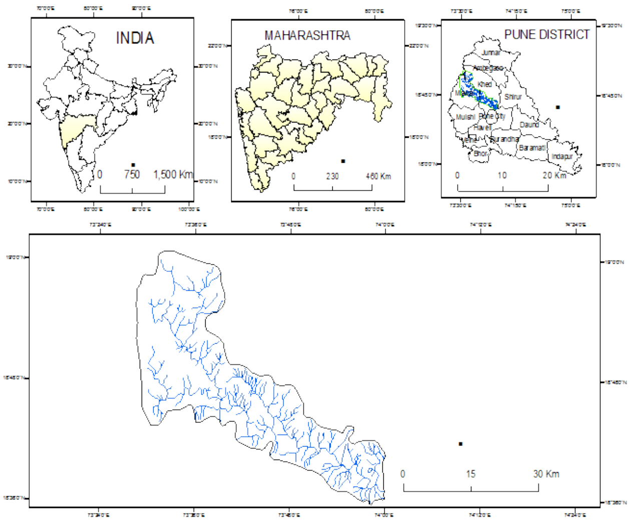
Fig-1 depicts the study area comprising of the river, the two pilgrim towns of Alandi and Dehu along with the locations of water quality sampling stations. The main causes of pollution in the river water are due to rapid urbanization and direct uncontrolled discharge of household and industrial wastes and sewage. It was observed that residents of Dehu and Alandi and other residents along river Indrayani and millions of pilgrims visiting these places are continued to be exposed to unsafe water and associated health risks. This paper presents a summary and discussion of the water quality data of river Indrayani for the year 2008-2009 and results and analysis of a health survey conducted during January-March 2009 in the study area.

III. METHODOLOGY

A. Water Quality Testing

In order to understand the effects of pollution, a 24 km long stretch of the river, extending from Bodakewadi to Charholi were selected for sampling. A total of 7 locations were selected along river Indrayani in Pune District as in Fig.1. Three sampling stations are located in the upper reaches of the river basin lying in and around boundaries of village Dehu. This stretch of the river network drains mostly thoroughly agricultural areas.

Dehu an important pilgrimage area is located in this stretch. Four sampling stations were selected in the lower reaches viz. Chikhali, Dudulgaon, Alandi Ghat, and Charholi. At Chikhali municipal sewage is discharged in the river. Anthropogenic activities such as open defecation, industrial discharge, and residential sewage are major causes of water pollution. At Alandi where 25,000 visitors visit daily and on an average 600 pilgrims take bath in river daily, sewage discharge, open defecation along river by visitors and local residents are the major sources of pollution.



DOI 10.5963/IJEP0201002

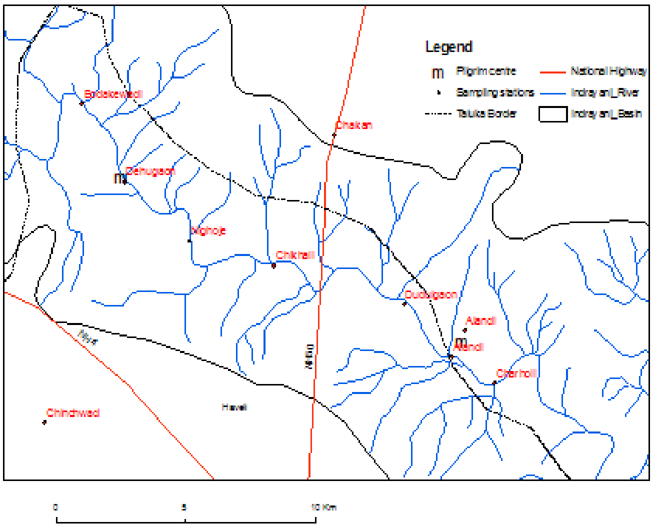


Fig. 1: Location and distribution of sampling sites along the Indrayani River

Charholi is downstream of Alandi and there is no major source of pollution except agricultural runoff. In order to understand the water quality of river Indrayani the water samples were collected and analyzed seasonally as well as before, on and after important pilgrimage days, such as Ashadhi Ekadashi (June) and Kartiki Ekadashi (November) as per the standard guidelines [15] (APHA, AWWA, WPCF, 1998). Water samples were collected in the month of March, July, and November for seasonal analyses. For pilgrimage period sampling, three samples were collected 1) three days earlier, 2) on the pilgrimage day and 3) three days later of the pilgrimage day. The water samples were collected during the period from March 2007 to April 2008.

For assessment of river water quality parameters such as pH, Turbidity, TDS, DO, BOD, COD, E.coli (cfu/100 ml) and Total Viable Count- TVC (cfu/100ml) were selected. The range of variation of water quality parameters for different temporal periods covering the two pilgrim periods and seasonal non pilgrim period were assigned subjective weights to evolve composite water quality index (CQI) for the different temporal periods and in the two zones of the study area. The range of subjective weights varied from 1 to 9, a weight of 1 indicates good water quality and range of 9 means highly polluted water quality (Table-1). The permissible CQI Values in excess of 25 means that the water is polluted beyond the permissible limit. The CQI values were computed for the three zones of the study area covering three temporal period combinations, viz; Combination-I seasonal, Combination-II Ashadhi and Combination-III Kartiki). The details are given in Table 2, 3 and 4 respectively.

The CQI values were designed to range from 5 to 45, the values of 5 was for very low water pollution that gave very less water quality parameter values and the value is 45 for highly polluted water with high values of water quality parameters exceeding the permissible limits.

TABLE 1: RANGE OF WEIGHTS AND ASSIGNED WEIGHTINGS BASED ON STRENGTH OF WATER QUALITY PARAMETER VALUES

Range of BOD (mg/L)	**Wt**	**Range of DO (mg/L)**	**Wt**	**Range of TDS(mg/L)**	**Wt**	**Range of E-Coli (cfu/100mL)**	**Wt**	**Range of TVC (cfu/100mL)**	**Wt**
1-6	1	8.5-9	1	0-25	1	0-100	1	0-500	1
6-12	2	8.0-8.5	2	25-50	2	100-200	2	500-1000	2
12-18	3	7.5-8.0	3	50-100	3	200-300	3	1000-1500	3
18-24	4	7.0-7.5	4	100-200	4	300-400	4	1500-2000	4
24-30	5	6.5-7.0	5	200-500	5	400-500	5	2000-2500	5
30-36	6	6.0-6.5	6	500-600	6	500-10000	6	2500-100000	6
36-42	7	5.5-6.0	7	600-700	7	10000-60000	7	100000-300000	7
42-48	8	5-5.5	8	700-800	8	60000-90000	8	300000-500000	8
48-54	9	4-4.5	9	>800	9	>90000	9	>500000	9
Permissible limit for BOD =30mg/L is given a weight 5		Permissible limit for DO =5mg/L is given a weight of 5		Permissible limit for TDS=250mg/L is given a weight of 5		Permissible limit for E.coli=10mg/L is given a weight of 5		Permissible limit for TVC =100mg/L is given a weight of 5	

TABLE 2: MULTI-CRITERIA WATER QUALITY MATRIX FOR WATER QUALITY PARAMETERS FOR SEASONAL PERIOD

Temporal period	**Pre-monsoon**				**Monsoon**				**Post-monsoon**			
Water quality parameter	Zone I	Zone II	Zone III	Mean Wt	Zone I	Zone II	Zone III	Mean Wt	Zone I	Zone II	Zone III	Mean Wt
BOD (mg/L)	1.33	5.5	5.5	4.11	1.33	4.5	4.5	3.44	1	4	4	3
DO (mg/L)	3	5.5	5.5	4.66	2.33	4.5	4.5	3.77	1.66	4	4	3.22
TDS (mg/L)	1.33	4	4	3.11	2	4	4	3.33	1.33	3.5	4	2.96
E. coli (cfu/1100ml)	6	6	7	6.33	6.66	7	7	6.88	6.33	6	7	6.44
TVC (cfu/110ml)	6.33	7	7	6.77	7	7	7	7	6.66	7	7	6.88
*CQI	17.99	28.00	29.00	24.98	19.32	27.0	27.00	24.42	16.98	24.5	26	22.5
Overall CQI												**23.97**
*CQI=sum of weights of individual water quality parameters												

DOI 10.5963/IJEP0201002

TABLE 3: MULTI-CRITERIA WATER QUALITY MATRIX FOR WATER QUALITY PARAMETERS FOR ASHADHI PERIOD

Temporal period	**Pre-ashadhi**				**Ashadhi**				**Post-ashadhi**			
Water quality parameter	**Zone I**	**Zone II**	**Zone III**	**Mean Wt**	**Zone I**	**Zone II**	**Zone III**	**Mean Wt**	**Zone I**	**Zone II**	**Zone III**	**Mean Wt**
BOD (mg/L)	1.66	4.5	4.5	3.55	1.66	5	4	3.55	1.66	4.5	5	3.72
DO (mg/L)	2	4	5.5	3.83	2	4	5	3.66	2	4	5.5	3.83
TDS (mg/L)	1.66	3	3.5	2.72	2	3	3.5	2.83	2	3	3.5	2.83
E. coli (cfu/1100ml)	6.66	7	7	6.88	7	7	7	7	7	7	7	7
TVC (cfu/110ml)	6	6	7.5	6.5	6	6.5	6.5	6.33	6	6.5	6.5	6.33
*CQI	17.98	24.5	28	23.48	18.66	25.5	26	23.37	18.66	25	27.5	23.71
Overall CQI												**23.53**
*CQI=sum of weights of individual water quality parameters												

TABLE 4: MULTI-CRITERIA WATER QUALITY MATRIX FOR WATER QUALITY PARAMETERS FOR KARTIKI PERIOD

Temporal period	**Pre-kartiki**				**Kartiki**				**Post-kartiki**			
Water quality parameter	**Zone I**	**Zone II**	**Zone III**	**Mean Wt**	**Zone I**	**Zone II**	**Zone III**	**Mean Wt**	**Zone I**	**Zone II**	**Zone III**	**Mean Wt**
BOD (mg/L)	1.66	5	6	4.22	1.66	5	6	4.22	1.66	5	6.16	4.27
DO (mg/L)	2	4.5	6	4.16	1.66	4	6	3.88	1.66	4	5.5	3.72
TDS (mg/L)	2	3.5	4	3.16	1.66	3.5	4	3.053	2	3.5	3.5	3
E. coli (cfu/1100ml)	3	6	5	4.66	3	4.5	7	4.83	4.33	7.5	6	5.94
TVC (cfu/110ml)	6	6.5	7	6.5	6	6	6.5	6.16	6	7.5	7	6.83
CQI	14.66	25.5	28	22.7	13.98	23	29.5	22.143	15.65	27.5	28.16	23.76
Overall CQI	*CQI=sum of weights of individual water quality parameters											22.87

B. Health Survey

A survey of resident users of the Indrayani River was conducted in between January-March 2008. Questionnaire was used for the household health survey conducted at Bodakewadi (control station), Dehu and Alandi. The head of the family was interviewed and asked to provide information for all members of the family. All family heads surveyed at Bodakewadi, Dehu and Alandi were confirmed to be residents of these places. For the religious bathing sites of Dehu and Alandi Ghat religious bathers and other water users were approached and questioned directly on the river bank. Questionnaires were prepared for both local residents and pilgrims asking specifically about their association with river ecosystem, water use practices, health impacts and overall health consequences before, during and after pilgrimage. The details of health survey were evaluated for the water borne disease of AGI having a predominant level of occurrence in the study area. The evaluation of occurrence of AGI disease amongst the local residents in Alandi and Dehu has been linked with various parameters compiled in the questionnaire on health survey by computing a parameter called as Odd Ratio (OR) for those parameters. The OR value gives an inference about the relative disease risk for an exposure factor.

Relative disease risk for an exposure factor is calculated using the formula: $P=pe/pu$

where, pe = number of exposed people with disease/total number exposed to a factor and pu = Number of unexposed people with disease/total number unexposed to a factor. The odds ratio (OR), which is the odds of disease in exposed people divided by the odds of disease in unexposed people, is closely related to relative risk. The value of OR for the two pilgrim towns of Alandi and Dehu was computed for various factors causing the Acute Gastrointestinal Infection (AGI). It is observed that with increase in occurrence of AGI disease for a given factor, there will be reduction in the value of OR and also there is a negative correlation between CQI and OR.

This will mean that an increase in value of CQI is associated with higher pollution of water due to higher values of water quality parameters along with more impact for occurrence of AGI indicated by lower values of OR. The various factors considered for computing OR values for AGI disease are the factors responsible for causing AGI. These are educational background, economic status; behavioral practices such as open defecation, personal hygiene, washing of clothes and utensils in river and poor sanitary conditions. The OR values responsible for causing AGI pertaining to different parameters for the data collected during sampling are given in Table 5 for both Alandi and Dehu. Figure 2 gives the details of OR in respect of various factors for the towns of Alandi and Dehu for the sample data.

DOI 10.5963/IJEP0201002

TABLE 6: ODDS RATIO (OR) FOR DIFFERENT PARAMETERS AT DEHU AND ALANDI

Sr. No.	Parameter/factor	Dehu (OR)	Alandi (OR)
1	Exposed to garbage	0.44	0.42
2	Exposed to wastewater	0.55	0.58
3	Lower Education	0.63	1.21
4	Lower occupation	0.70	0.59
5	Toilet to pilgrims	0.73	0.77
6	Lower income	0.93	0.77
7	Higher Education	1.18	2.20
8	No water sufficiency	1.34	0.72
9	Exposed to bad water quality	1.34	0.66
10	Higher income	1.39	1.52
11	Poor sanitary conditions	1.55	1.15
12	Shelter to pilgrims	1.68	1.68
13	No hygiene	1.94	1.58
14	Higher occupation	2.12	1.81
15	Rented house	2.43	1.12

TABLE 7: RESIDUAL ERROR, CQI AND OR FOR THE FITTED EQUATION

Sampling Stations							
Dehu				Alandi			
CQI	OR computed	OR estimated	Residual error	CQI	OR computed	OR estimated	Residual error
29	0.42	0.379	0.041	29	0.42	0.992	-0.572
28.16	0.51	0.58564	-0.07564	28.16	0.51	1.171894	-0.66189
28.16	0.51	0.58564	-0.07564	28.16	0.51	1.171894	-0.66189
28	0.66	0.625	0.035	28	0.66	1.206	-0.546
28	0.66	0.625	0.035	28	0.66	1.206	-0.546
27.5	0.77	0.748	0.022	27.5	0.77	1.31225	-0.54225
27	0.77	0.871	-0.101	27	0.77	1.418	-0.648
26	1.12	1.117	0.003	26	1.12	1.628	-0.508
26	1.12	1.117	0.003	26	1.12	1.628	-0.508
25.5	1.21	1.24	-0.03	25.5	1.21	1.73225	-0.52225
25	1.52	1.363	0.157	25	1.52	1.836	-0.316
24.5	1.58	1.486	0.094	24.5	1.58	1.93925	-0.35925
23	1.68	1.855	-0.175	23	1.68	2.246	-0.566
22.7	1.81	1.9288	-0.1188	22.7	1.81	2.30681	-0.49681
22.14	2.2	2.06656	0.13344	22.14	2.2	2.41984	-0.21984

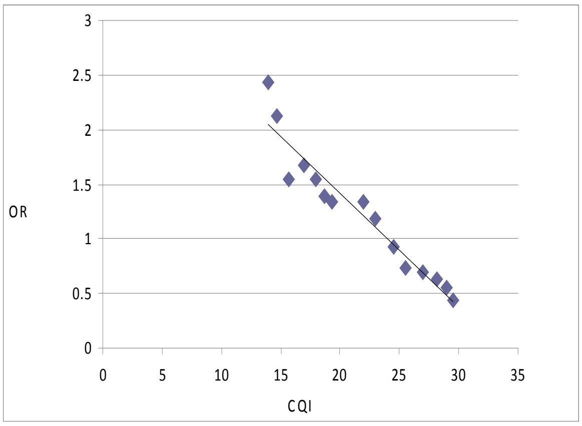
IV. RESULTS AND DISCUSSION

It was observed that temporal CQI variation for combination period I, II, III for Alandi and Dehu area varies temporally. Accordingly the temporal CQI value variation occurring during pilgrimage periods and non pilgrimage periods has been correlated with OR associated with AGI disease computed for various factors to assess the likely impact of water quality parameters converted as a composite quality parameter (CQI) with occurrence of AGI indicated as value of OR and also to analyze the increase in impact of AGI due to pilgrim activities during pilgrim periods indicated by reduction in OR value. Table 6 provides Odds Ratio (OR) values for different parameters where as Fig. 3 illustrates the variation of CQI with OR for Alandi and Dehu along with the equation for best fit curve.

DOI 10.5963/IJEP0201002

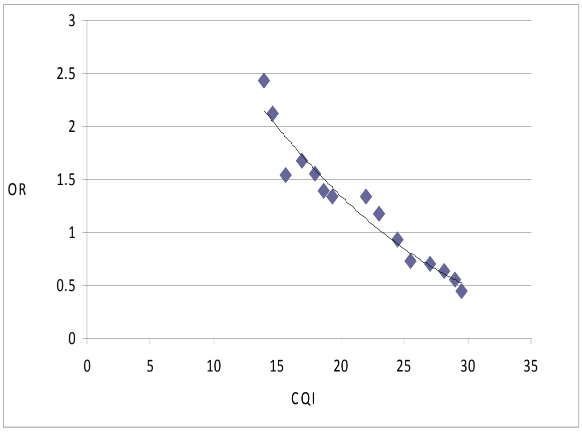
There is a negative correlation between CQI and OR with the Pearson’s correlation coefficient being 0.958 for Alandi and 0.964 for Dehu. Curve fitting between CQI and OR was carried out and the results gave less residual errors between the observed and estimated values for first order equation in Alandi while the fitted curve of second order gave least residual error between the observed and estimated values for Dehu. Table 7 gives details of residual errors for the fitted curves in Alandi and Dehu along with their respective variance and standard deviation values. The residual errors are observed to be within the permissible limits and are having a variance of 0.015761 for Alandi and 0.008787 for Dehu respectively and Standard Deviation of 0.1255 and 0.09374 for Alandi and Dehu respectively.

This implies that the fitted curve can be reliably applied to assess the likely impact of pilgrims during the pilgrim periods. It is observed that there is a trend of increase in the value of CQI from 24 during non-pilgrim period to 26 during the pilgrim period of Ashadi and between 26 during non pilgrim period to 28.16 during the pilgrim period of Kartiki in Alandi.



$Y=-0.1039x+3.4941 \quad R^2=0.9194$

EQUATION FOR ALANDI



Y=-0.003x2 -0.235x+4.8452 R2=0.9318

EQUATION FOR DEHU

Fig 3: Variation of CQI with OR for Alandi and Dehu along with the equation for best fit curve

There is a negative correlation between CQI and OR with the Pearson’s correlation coefficient being 0.958 for Alandi and 0.964 for Dehu. Curve fitting between CQI and OR was carried out and the results gave less residual errors between the observed and estimated values for first order equation in Alandi while the fitted curve of second order gave least residual error between the observed and estimated values for Dehu. Table-7 gives details of residual errors for the fitted curves in Alandi and Dehu along with their respective variance and standard deviation values.

The residual errors are observed to be within the permissible limits and are having a variance of 0.015761 for Alandi and 0.008787 for Dehu respectively and Standard Deviation of 0.1255 and 0.09374 for Alandi and Dehu respectively. This implies that the fitted curve can be reliably applied to assess the likely impact of pilgrims during the pilgrim periods. It is observed that there is a trend of increase in the value of CQI from 24 during non-pilgrim period to 26 during the pilgrim period of Ashadi and between 26 during non pilgrim period to 28.16 during the pilgrim period of Kartiki in Alandi. In the same manners it is observed that there is a trend of increase in CQI value from 26 to 28 during pilgrim period of Ashadi and 28 to 29.5 during the pilgrim period of Kartiki in Dehu.

This trend of increase in CQI values has resulted in reduction of OR values during pilgrim periods in comparison with non pilgrim periods and therefore the reduction of OR value can be an assessing factor in arriving at the percentage increase in impact of occurrence in AGI disease amongst the local population at both Alandi and Dehu. In terms of impact for AGI disease expressed as a percentage increase during pilgrim periods, it is observe that there is 49 to 63 percent reduction in OR values during Ashadi and Kartik pilgrim periods at Alandi indicating an increase in number of cases of AGI associated with various factors considered in the study. In the same manner the percent reduction in OR values are 28 and 32 for the two pilgrim periods at Dehu, which means that there is same trend of increase in AGI occurrence due to various factors during pilgrimage at Dehu also. The various issues pertaining to deterioration of water quality due to activities of pilgrims and local residents has resulted in various health disorders to both the local residents and to pilgrims.

Some symptoms observed in the regular and irregular bathers at the Ghats of Dehu and Alandi are: 32% regular bathers complained about skin irritation problems at Alandi Ghat while 16.36% bathers at Dehu Ghat complained about skin irritation. At the Ghats of Alandi 27.07% complained about quality of water and felt awkward while taking bath. Subsequently 10.81%, 5.4%, 10.81%, 27.07%, 2.75% and regular bathers at the ghats of Alandi complained about toothache, ear pain, throat irritation, feeling of vomiting and stomachache respectively in comparison with 7.14%, 7.27%, 3.62%, 1.81% and 0% respectively at Dehu. The tap water quality at Alandi was bad due to foul smell, color in water and presence of colloidal impurities which has been reflected in household health survey response in which 44% population complained about bad water quality. This has been attributed to the excessive environmental degradation in the study area

DOI 10.5963/IJEP0201002

leading to ineffective water treatment process, improper solid waste management and untreated disposal of sewage into the river water.

V. CONCLUSION

Environmental degradation due to various activities of pilgrims and local population, untreated disposal of domestic and industrial effluents at Alandi and Dehu towns locate on the banks of River Indrayani has resulted in deterioration of water quality in River Indrayani. This has resulted in increase in occurrence of waterborne diseases amongst the local population of both the towns especially AGI and other health hazards for pilgrims and visitors. The deterioration of water quality due to various causative factors can be associated with outbreak of AGI disease by establishing relationships between quantified water quality factors with quantified health related parameters for AGI evolved from various factors responsible for occurrence of AGI. This can be useful in assessing the likely increase in impact of waterborne diseases including AGI during pilgrimage period caused due to activities of pilgrims.

REFERENCES

[1] Esrey S.A. and Habichat J-P. Epidemiological evidence for health benefits from improved water and sanitation in developing countries. Epidemiological Reviews Oxford University Press, 8, pp. 117-128, 1986.

[2] WHO, Combating waterborne disease at the household level / International Network to Promote Household Water Treatment and Safe Storage, World Health Organization, NLM classification: WA 675, pp 7-34, 2007.

[3] The World Bank, Water, Sanitation and Children’s Health, Evidence from 172 DHS Surveys, The World Bank Development Economics Prospectus Group, Policy Research Working Paper, April, , pp 1-36 2010.

[4] Hamner S., Tripathi A., Mishra R., Bouskill N., Broadway S., Pyle B. and Ford, Role of water use patterns and sewage pollution in incidence of water-borne enteric diseases along the Ganges River in Varanasi, India, Int J. Env. Health Res., April; 16 (2): 113-132, 2006.

[5] Anderson and Bohan, Disease surveillance and waterborne outbreaks In: Ed. Fewtrell and Bartram, World Health Organization Water Series, IWA Publishing UK, Chapter 6 pp. 115-133 2001.

[6] Payment Pierre and Hunter Paul, Endemic and epidemic infectious intestinal disease and its relationship to drinking water In: Ed. Fewtrell and Bartram, World Health Organization Water Series IWA Publishing UK, Chapter 4, pp 70-92 2001.

[7] Richard Carr and Martin Strauss, Excreta related infections and the role of sanitation in the control of transmission In: Ed. Fewtrell and Bartram World Health Organization Water Series, IWA Publishing UK, , Chapter 5, pp 92-114 2001.

[8] S. Kumar Karn and Harda, Field survey on water supply, sanitation and associated health impacts in urban poor communities – a case from Mumbai City, India, Water Science and Technology, , (46) 11-12, pp 269-275 2002.

[9] Eisenberg J, Brrokharth M.A, Rice G, Brown M, and Colford J.M., Disease Transmission Models for Public Health Decision Making: Analysis of Epidemic and Endemic Conditions Caused by Waterborne Pathogens, Environmental Health Perspectives, (110) 8, pp, 783-790 2002.

[10] Colwel Rita, Infectious disease and environment: cholera as a paradigm for waterborne disease International Microbiology, (7) 4 pp 32-40 2004.

[11] Grabow W., Waterborne diseases: update on water quality assessment and control, Water SA, (22) 2, pp 193-205 1996.

[12] Brick Thomas, Primrose Beryl, Chandrashekhar R, Roy Sheela, Jayprakash Muliyil and Gagandeep Kang, Water contamination in urban south India: household storage practices and their implications for water safety and enteric infections, Int. J. of Hygiene and Env. Health, (207) 5 pp 473-480 2005.

[13] Kocasoy Gunay, The relationship between coastal tourism, sea pollution and public health: a case study from Turkey, Springer, (9) 4, pp, 245-2511989.

[14] Government of India Rural Drinking Water and Sanitation in the eleventh plan period-excerpts, Planning Commission, Eleventh Five Year Plan (2007-2012) New Delhi, 2007.

[15] APHA, AWWA and WPCF Standard methods for the examination of Water and Wastewater Eds. A.D. Eaton, L.S. Cleseri and A.I. Greenberg, 20th ed., American Public Health Association, 1998.

Sanjay M. Marale born at Palus in Sangli District of Maharashtra (India) on March, 20th 1976. He completed his post graduation in Environmental Science from Shivaji University Kolhapur in 1999. He received his Ph.D degree in September, 2011 from University of Pune (India). His major field of study is Environmental Science.

Earlier he was working as a Research Associate at the Department of Environmental Sciences, University of Pune. Currently he is working as a Research Assistant at Society of Integrated Coastal Management (SICOM), New Delhi. His previous publications include 1. Multi-criteria assessment of different temporal water quality changes causing impact on public health and environmental degradation ***Int. J. Integ. Biol., 2010, 9(3): 123-127*** **2.** Status of coastal habitats and its management in India ***IJEP (1)1:2011; 31-45 and*** 3: Comparative analysis of noise pollution in pilgrimage places from Maharashtra, India, ***Enrich Environment, Multi. Int. Res. J.*** His research interests lie in Ecosystem Based Management and Environment Education.

Dr. Marale has recently qualified State Eligibility Test (SET) conducted by University Grants Commission (UGC) in India for lectureship in the subject of Environmental Science.

Dnyaneshwar M. Mahajan completed his post graduation in Botany from Universty of Pune. He received Ph.D in Environmental Sciences, from Department of Environmental Sciences University of Pune. Presently he is Associate Professor at Waghire College, Saswad, Pune. He is a visiting faculty at Department of Environmental Science, University of Pune.

Ravindra S. Gavali received Ph.D from Jawaharlal University, New Delhi. He was working as Assistant Professor at University Of Pune. Presently he is working as Associate Professor at University of Solpaue (India).

Kumar R. Rao has received two Ph.D degrees, one from India and other from U.S.A. Presently he is working as a Professor at College of Military Engineering Khadaki, Pune (India). He is a visiting faculty at University of Pune.

DOI 10.5963/IJEP0201002