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IMPACT OF HUMAN ACTIVITIES ON THE QUALITY OF WATER IN THE MUTHA RIGHT BANK CANAL, PUNE CITY AREA

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ABSTRACT : Chemical analysis of water samples from the Mutha Right Bank canal shows that the canal water is characterised by the presence of alkaline earths and week acids. Moreover, downstream from Khadakwasla lake, the chemical nature of the water changes from HCO_3^- type to $Cl^- + SO_4^{2-}$ type suggesting progressive contamination because of human activities. Bacterial analyses support these conclusions. Remedial measures for improvement of water quality are suggested.

INTRODUCTION

Pune, a historic city, known for its cultural and educational activities has undergone considerable industrialisation in recent years, and especially after the Maharashtra Industrial Development Corporation sponsored the development of industrial areas in and around the city. In the 1940's it had 107 industrial units employing about 1500 workers. A decade back, there were about 2500 factories employing around 150,000 workers (Industrial and Commercial Directory of Pune, 1979) and the indications are that the exponential growth has continued. The population of the city which was 4,82,600 in 1951, crossed the million mark in 1981 and is probably about 1.6 million today. Along with urban and industrial development, there has been large scale migration of people from rural areas to seek jobs in Pune. Consequently, a large number of hutment colonies have come up all over the metropolis. Ungainly, zopadpattis have developed on hillslopes and along water courses. In the area studied, these include the hutments, of Parvati hill, Ambil nala and Sinhgad road (Fig. 1). The activities of dwellers of these hutments is in the vicinity of the Mutha Right Bank Canal and has had an impact on the quality of water passing through it. This has serious repercursions as the canal is the main source of water supply to Pune city for drinking and domestic purpose.

The Mutha Right Bank Canal passes through several villages and hutment colonies before its water is delivered to the Parvati Water Works, for everyday supply. The ever increasing population in the upstream villages and slums have forced the authorities to construct ghats on the banks of the canal for direct use. The natural quality of canal water has considerably degraded because of human activities in the vicinity of the canal. Increased demands and contamination have together placed an intolerable burden on the canal waters and has resulted in public awareness for corrective measures. The contamination of canal is clearly reflected by the telltale appearance, colour, odour and sediment content. The increased susceptibility of this drinking water source to pollution, through waterborne diseases is likely to pose some serious health problems. Therefore, taking into consideration the urgent necessity of evaluating the extent of contamination of drinking water, the authors undertook a detailed study of the quality of water in the Mutha Right Bank Canal. It includes an assessment of natural and altered characters of the canal water and its suitability for drinking purpose.

THE CANAL : AN INTRODUCTION

The Mutha Right Bank Canal originates from Khadakwasla dam, situated about 17.6 km. west of Pune city. The canal is used for drinking and agricultural water

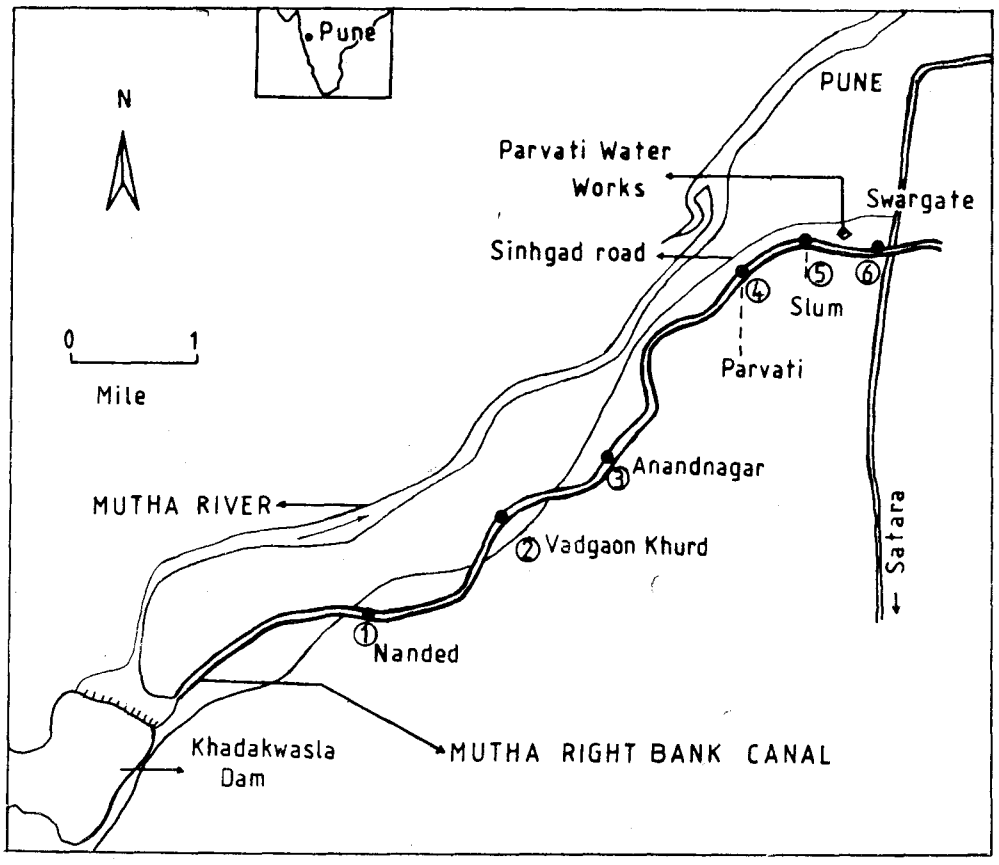

Fig. 1. Location Map of the Mutha Right Bank Canal, showing Water Sampling Stations

supply. It brings Water from Khadakwasla dam to Parvati water Works, from where it is supplied for drinking purpose. The Pune Municipal Corporation supplies about 80 million gallons of water per day to the city from the total discharge (31 m^3/sec.) of water to the canal from the Khadakwasla dam. The canal further traverses through the eastern semiarid parts of Pune district and augments mainly irrigation and partly drinking water requirements. The total length of the canal is about 220 km. of which the first 20 km. (Khadakwasla to Hadapsar) is lined. The cement concrete lining of the canal maintains steep slopes to prevent easy withdrawal of the water. As pointed out earlier, the canal passes through several villages and hutment colonies on its way from Khadakwasla to Parvati Water Works. The construction of ghats in these villages has enabled people to make direct use of canal water for drinking, washing and bathing purposes. There are about six such ghats between Khadakwasla and the Water Works which are the main polluting localities. In addition, cracked and dislocated concrete lining of the canal at many places adds natural earth material to this water.

MATERIALS AND METHODS

The criteria adopted by the Global Environmental Monitoring Systems/Water Programme (GEMS/WATER) and suggested

by Helmer (1981) were followed while selecting the water sampling stations for monitoring of the water quality. The sampling and analysis was undertaken thrice in 1982–83.

Sampling Stations

Six sampling stations were identified along the Mutha Right Bank Canal from Khadakwasla to Swargate (Fig. 1). The first sampling station (Spot No. 1) is located at Nanded, characterised by natural and uncontaminated water, as it is in the immediate vicinity of the Khadakwasla reservoir. The second station (Spot No. 2) is located at Vadgaon Khurd, immediately downstream of the village ghat. The remaining stations (Spot Nos. 3, 4 and 5) are situated between Vadgaon Khurd and the point of abstraction of water to Parvati Water Works. The last sampling station (Spot No. 6) is located downstream of the intake point.

Analyses of the Water Samples

The chemical analysis of water samples included determination of fifteen physico-chemical parameters for each sample. These comprised the analyses of routine parameters such as temperature, pH and electrical conductance. The temperature affects chemical equilibrium, pH, electrical conductance and dissolved ions present in the water, while conductivity gives an idea about total dissolved solids content in the water. The pH of water represents interrelated result of a number of chemical equilibria (Hem, 1970). It was therefore, felt essential to include these parameters in the analysis. The determination of these parameters was carried out in the field with the help of portable water quality analysers.

In addition to the above, other parameters included in the analysis were dissolved oxygen (D.O.), total alkalinity, chloride, sulphate, phosphate, nitrate, nitrite and total hardness. In this group of parameters the chloride, sulphate, nitrate, nitrite and phosphate (except dissolved oxygen), were considered as contaminants because the host rock (basalt) contributes them in very meager quantities. The very presence of these parameters, therefore, can be directly related to the human activities. The dissolved oxygen on the other hand, is an indicator of the biochemical status of water with respect to time and space (Trivedy and Goel, 1984). The analysis of D.O., total alkalinity, hardness, chloride and sulphate was carried out volumetrically, while colourimetric methods were used for nitrate, nitrite and phosphate.

Apart from the above given parameters, alkali (Na^+ and K^+) and alkaline earth (Ca^{2+} and Mg^{2+}) elements were included in the water analysis. The presence of these elements in water reflect the contribution from the host rock (Matthess and Harvey, 1982). The alkali elements were analysed by flame photometric techniques and calcium was determined by titrimetric procedure. The calculation method (I.S.I., 1979) was applied for magnesium determination. Chemical procedures used, were standardised in accordance with APHA et al. (1976).

RESULTS

Chemical Data

It is observed from the data (Table I) that the D.O. values go on decreasing from Nanded to Swargate in all the three seasons (Fig. 2a). This suggests that the quality of water is deteriorating gradually, which is evident from subsequent increase in the values of phosphate (Fig. 2b). The nitrate and nitrite concentrations also increase from Khadakwasla to Swargate (Table I). The nitrites exceed the permissible limits laid down by World Health Organisation (1972) and Indian Standards Institution (1974). According to WHO (1972) specifications, nitrite should be virtually absent in the drinking water and as per ISI (1974), it should be below 0.005 mg/lit. However, the values obtained for the Spot No. 3, 5

TABLE I—Physio-chemical characters of the water from Mutha Right Bank Canal, Pune City Area

No.	Locality Name	Temp. °C	pH	Cond. μs/cm	D.O.	HCO_3	Cl	Hard.	SO_4	PO_4	Nitrate		Nitrite		Na	K	Ca	Mg
											N	NO_3	N	NO_2				
	Winter Season 1982–83																	
1	Nanded ..	22	7.4	73	9.6	50	20	140	36	Nil	Nil	Nil	Nil	Nil	2.0	0.5	31	11
2	Vadgaon Khurd ..	22	8.0	80	9.2	90	20	200	68	0.10	Nil	Nil	Nil	Nil	6.0	0.5	44	10
3	Anandnagar ..	22	7.5	67	3.2	90	20	160	35	0.15	Nil	Nil	0.003	0.0098	2.0	0.3	35	10
4	Parvati ..	24	7.8	76	4 4	80	25	150	56	0.25	0.08	0.3554	0.002	0.006	2 0	0.5	33	9
5	Parvati Slum ..	24	7.6	75	4.0	56	20	160	43	0.30	0.27	1.196	0.003	0.0098	2.0	0.5	35	9
6	Swargate ..	22	7.7	73	6.0	60	25	190	48	0.30	0.08	0.3554	0.0025	0.0082	6.0	0.5	18	10
	Summer Season 1982–83																	
1	Nanded ..	26	6.2	58	5.2	50	5	60	33	Nil	Nil	Nil	Nll	Nil	1.0	Nil	12	8
2	Vadgaon Khurd ..	25	7.0	90	5.5	50	10	60	33	0.20	0.26	1.15	Nil	Nil	1.0	Nil	10	8
3	Anandnagar ..	25	6.8	90	5.4	30	5	80	35	0.20	0.23	1.0189	Nil	Nil	1.0	Nil	16	6
4	Parvati ..	26	7.4	81	5.0	50	10	80	52	0.25	Nil	Nil	Nil	Nil	1.0	Nil	16	6
5	Parvati Slum ..	26	7.3	57	5.0	20	10	80	41	0.40	Nil	Nil	0.002	0.006	1.0	Nil	16	6
6	Swargate ..	26	6.9	61	4.6	50	10	90	32	0.40	Nil	Nil	0 0025	0.0082	1.0	Nil	18	2
	Rainy Season 1982–83																	
1	Nanded ..	30	8.1	228	8.0	150	50	110	19	Nil	Nil	Nil	Nil	Nil	2.0	0.5	22	8
2	Vadgaon Khurd ..	30	8.2	253	7.4	150	55	120	62	Nil	0.14	0.6202	Nil	Nil	3.0	0.1	23	10
3	Anandnagar ..	30	8.1	269	6.5	140	35	130	64	Nil	0.12	0.532	Nil	Nil	2.0	0.1	26	10
4	Parvati ..	41	8.0	330	6.3	160	125	160	50	Nil	Nil	Nil	Nil	Nil	3.0	0.1	32	12
5	Parvati Slum ..	27	8.1	349	6.6	170	95	170	48	Nil	Nil	Nil	Nil	Nil	2.0	0.1	36	10
6	Swargate ..	31	8.2	317	5.7	180	70	150	25	Nil	Nil	Nil	Nil	Nil	4.0	0.1	30	10

(All the results are reported in mg/lit except pH. temperature and conductivity).

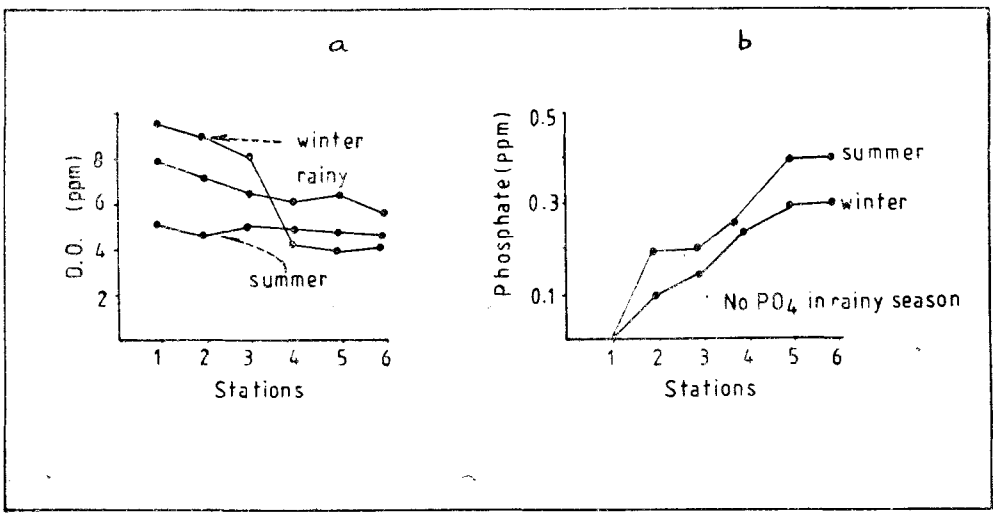

Fig. 2a and b. Graph showing Concentrations of Dissolved Oxygen and Phosphate along the Mutha Right Bank Canal

and 6 are as high as 0.009 mg/lit. Out of these, the Spot No. 3 and 5 are situated just upstream of point of abstraction of water. The phosphate values at these spots are also upto 0.4 mg/lit., which are mainly contributed to the water from detergent soaps used for washing and bathing purpose on the ghats. Thus, decrease in the D.O. values accompanied by increase in the phosphate, nitrate and nitrite values indicate domestic sources of inorganic pollution of water.

Bacterial Data

Godbole (Pers. comm.) has carried out studies on the bacterial quality of the canal water under review. His studies, have shown that in the samples collected from Khadakwasla dam, every 100 ml. of water contains 170 coliform bacteria and about 1.6 mg/lit of BOD. The coliform bacteria at Vadgaon Khurd increased upto 9000/100 ml. of water and BOD values upto 2.4 mg/lit. Similarly, 4.10 mg/lit. of BOD and coliform bacteria as high as 16,000/100 ml. of water were observed near the point of abstraction. The high BOD values accompanied by high bacterial count, suggest that water is not quite safe for drinking purpose.

GEOCHEMICAL CHARACTERS OF WATER

In order to compare the analyses of all the sample spots and to highlight the differences and similarities, the chemical data was plotted on Piper's Trilinear Diagram (Piper, 1953). The plots of the data on this diagram (Fig. 3a, b and c), show that the alkaline earths exceed alkalies ($Ca^{2+} + Mg^{2+} > Na^{+} + K^{+}$). Amongst anions generally, weak acids exceed strong acids ($HCO_3^- > Cl^+ + SO_4^{2-}$), though in a few cases (Spot Nos. 3, 4 and 5) strong acids exceed weak acids. The samples from the latter spots also show that secondary alkalinity (non-carbonate hardness) exceeds fifty percent. However, rest of the samples exhibit secondary alkalinity (carbonate hardness) exceeding fifty percent. Therefore, the chemical properties of water are dominated by alkaline earths and weak acids.

A careful examination of Fig. 3a, b and c indicates that there is gradual change in the chemical characters of water. The

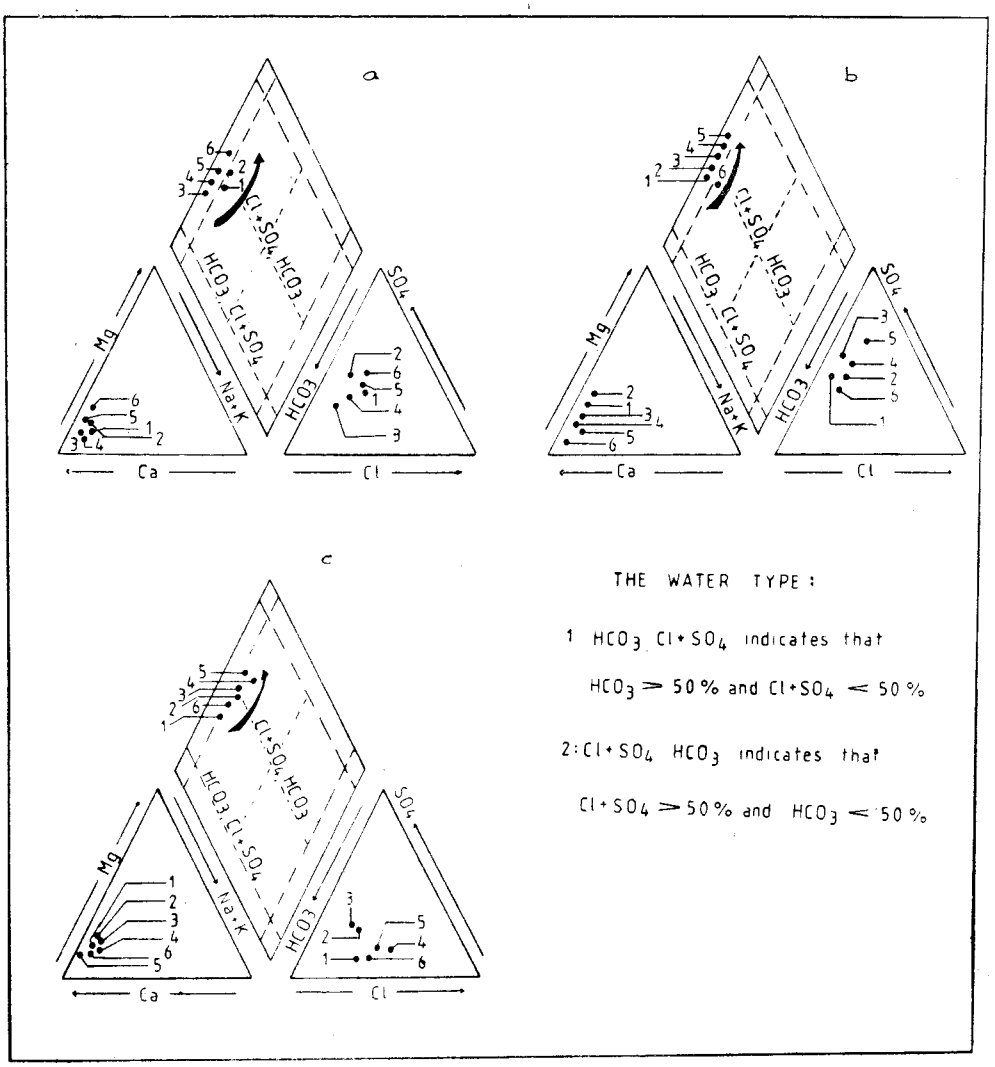

Fig. 3. Plots of the Chemical Data on Piper's Trilinear Diagram, showing Chemical Types of the Water (after Piper. 1953).

water type changes from HCO_3^- to that of $Cl^-+SO_4^{2-}$ type as shown by arrows in the diamond shaped area. This suggests that chlorides and sulphates are being added in the water. Considering the host rock composition, it can be noted that there is no source of these anions present in the rock. The possibility of host rock contribution can also be ruled out as the canal is lined, and broken lining cannot make noteworthy contribution. Therefore, the increase in the values of these parameters (Cl^- and SO_4^{2-}) can be associated with the human activities. The domestic use of water contributes these anions in significant quantities (Matthess and Harvey, 1982). Thus, evolution of water types (HCO_3^- to $Cl^-+SO_4^{2-}$) itself is an evidence of increasing contamination of water due to human activities.

DISCUSSION

The Mutha Right Bank Canal was protected by wire fencing in earlier days. However, due to increase in the population pressure, the villagers have pulled down the fence and have started using this water. Subsequently in order to cope up with the increasing demand for water the villagers were allowed by the concerned authorities to draw water directly from the canal for regular use. Ghats were constructed to facilitate direct access to the canal. This ultimately resulted in the misuse of the water. In addition, during the last 10 to 15 years, along the Parvati hillslopes a major unauthorised slum has come up, with inadequate water supply and sanitary facilities. Consequently, the slum-dwellers and the villagers started washing clothes, household untensils and domestic animals in the canal waters. Children as well as adults started using the canal as a swimming pool. As a result, the contribution of pollutants increased substantially in the canal water.

It is apparent from the above discussion that the principal source of contamination is human activity. The bacterial data provides sufficiently strong evidence in favour of this inference. The chemical data give further details of the changing nature of the geochemical characters of the canal water. The gradual change in the water types is aided by the contributing anions (Cl^- and SO_4^{2-}) that are found associated with the domestic wastes. The increase in phosphate is also noteworthy. The possible source of phosphate could be detergent soaps used for washing and bathing purposes on the ghats. This is because, generally tripolyphosphate is used as a builder in detergents. The higher nitrate and nitrite values are also related to human activities, as there is no significant agricultural activity practised in the canal vicinity.

EFFECTS ON THE HUMAN HEALTH

Recent researches have revealed that life is as much inorganic as organic. It is known that the major ions like sodium, potassium, calcium and magnesium alongwith a few transition elements are essential to sustain biologic life (WHO 1978a). However, these essential elements can become toxic when nutrutional supply becomes excessive (WHO 1978b). Eighty percent of the human body is water with dissolved physical and chemical constituents, therefore, the knowledge of water quality serves as a guide for protection of health from possible water-borne diseases.

In Pune, due to to poor quality of drinking water, cases of jaundice are on the rise. The higher concentrations of sulphate, accompained by higher chloride values are responsible for indigestion and gastric troubles (WHO 1978b). The hardness of water, due to presence of calcium and magnesium causes rheumatism and urinary infection (WHO 1978a). The increase in nitrate concentration is known to cause cynosis or blue baby disease. However, in Pune, while cases caused by nitrates are unknown, cases of indigestion and gastric troubles are common.

RECOMMENDATIONS FOR FUTURE WATER QUALITY IMPROVEMENT PROGRAMMES

It is obvious that urgent steps to prevent the pollution of water from the Mutha Right Bank Canal should be taken, otherwise obtaining potable water from this canal will be difficult in near future. Some preventive measures are given below :

(1) Human activity in the canal command area should be reduced.

(2) The villages situated on the banks of the canal should be provided alternative source of water. This can be achieved by installing pumps and storing water in tanks.

This will discourage people from going directly to the canal for withdrawing water.

(3) The inner walls of the canal should be re-lined.

(4) The construction of ghats near villages should not be allowed.

(5) The canal area should be made inaccessible for human use by re-erecting wire fencing.

(6) The best possible way is to bring water to the Parvati Water Works through closed pipes.

(7) Household treatment methods which are usually recommended, like boiling of water before use, addition of alum etc. can be undertaken.

SUMMARY AND CONCLUSION

The capability of man to alter his environment is unlimited and this is evident from the changes observed in the composition of canal water under review. In case of the test area the compositional changes can undoubtedly be linked to the activities of man. As long as unplanned development and urbanisation continues, the impact of man on his surroundings will continue unabated. Nevertheless, the purpose of the study is not to over-emphasise the water pollution problems but to highlight the extent of negligence on the part of the concerned authorities to tackle this problem. In view of the magnitude of the problem, any technological solution is likely to incur huge investment over a period of time. At this stage one should also consider that water by its nature and solvent properties gets contaminated easily. So in order to deliver uncontaminated water, an integrated package for water supply through contamination-free conduits, is imperative. At the same time sanitation, education and community-care facilities need to be provided in the areas along the canal. Such a programme will invoke strong support from the local population as the public awareness of water pollution is more than ever before.

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