The Ganga at Varanasi and a travail to stop her abuse*

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Ganga, the holiest of Indian rivers is highly polluted near many cities on its banks. The problem of pollution at Varanasi as at many other places, is due to sewage inflow, industrial waste, animal carcasses, unclaimed human bodies, plastic bags, etc. The biochemical oxygen demand is as high as 20 mg/l and faecal coliform counts is around 1.5 million/100 ml at downstream end of the city. This article deals with the most appropriate cost-effective technical solution. The efforts due to the Sankat Mochan Foundation and its Swatcha Ganga campaign have not fructified so far, even after more than two decades, due to apathy and prejudices of the executive. Our universities and professional bodies have to take a pro-active lead, be it cleaning rivers, environment or other spheres.

Keywords: Ganga pollution, sewage treatment, Sankat Mochan Foundation, Varanasi.

Varanasi, Ganga and the people

Varanasi (25°20′N and 83°7′E) is an ancient city situated on the left bank of river Ganga. The holy scriptures of India describe Varanasi as Kashi – a column of light and that Lord Shiva came down from Mount Kailash in the Himalayas to make Varanasi as His headquarters. Ganga in her 2500 km long journey from the Gomukh in the Himalayas to Ganga Sagar in the Bay of Bengal passes through Varanasi. The 7 km long river-face along the city of Varanasi extending from Asi to Varuna is a hallowed place. Today the famous ghats of Varanasi add to the grandeur of this holy river-face.

About 60,000 people take a holy dip in the Ganga at the ghats each day. There may be a few thousand people among them for whom Ganga is the medium of life. They have immense faith in the Ganga, are committed to her and cannot be separated from her. They want to have a ‘darshan’ of the Ganga, touch her water, submerge their body into her water and get ecstatic contentment by sipping her water. They cannot bear anybody saying that Ganga is sick and polluted. The culture and the faith related to the Ganga have survived for thousands of years because of these practising Hindus. They are ignorant of the present processes of development, science and technology. They do not have the present skills of articulation to interact with the modern world and also do not have a forum to do so. But they are gems born with the rich cultural heritage of India. When exposed to the modern world, they respond favourably to all good things which the world offers us today.

Urban growth – Pollution of Ganga

Another name for Varanasi in our holy texts is Anandvan, a forest of bliss. It has been a city of tanks and little forests, a peaceful place in pursuit of the metaphysical world. His Holiness Adi Shankaracharya said:

असारे खलु संसारे सारमेतत् चतुष्टयं,
काश्यां वासः सतां संगः गंगांभः शिव पूजनम्

(In the otherwise non-substantial world, the four substantials are: living in Kashi, the company of good people, water of the Ganga and worship of Shiva).

The world changed with the Industrial Revolution and other developmental processes. During the British period in India, Varanasi was given its due importance. A well-designed underground gravity sewage system for a population of 2 lakhs was laid in Varanasi, when flushed toilets were installed. Though no sewage treatment plant was installed, the sewage system was good enough to divert the city’s sewage away from the ghats. No sewage flowed into the Ganga in the religious bathing area. Other urban infrastructure needed for Varanasi was laid. The present population of the city is about 1.5 million. The infrastructure created for 200,000 people has not been improved. The sewage system has become old. People have started settling in low-level lands and on both sides of the small rivers, Asi and Varuna. People have started using storm water drains as sewer outfalls.

Master plans were made, suspended, discarded and changed due to political pressures. This has resulted in an

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unplanned development of Varanasi in the last 50 years. The capacity of the old sewers has been exceeded and the city's sewage and industrial waste flow into the river in the religious bathing area also, through 30 point sources, i.e. sewer outfalls, open drains and other outlets. The maximum population density of the city near Shri Vishwanath Temple is 100,000 per km^2. People have pet animals in their houses. No arrangement exists for solid waste disposal, including disposal of the animal carcasses. Firewood is becoming costlier everyday. It is difficult for the 'Shmashan Ghat' (cremation ground) to cope with the pressure of increasing number of cremations done on the river bank. The result has been abuse of mother Ganga. The total sewage and industrial effluent of Varanasi is flowing into the river along the ghats of Varanasi. Garbage, dead bodies of animals and unclaimed human bodies, plastic bags, etc. are also thrown into the river where people take a holy dip. In 1986, according to Government's estimates, about 147 million litres per day (MLD) of sewage and industrial waste generated in Varanasi flowed into the Ganga. Now, over 200 MLD of wastewater is flowing into the river.

Ganga's capacity to bear the aforesaid abuse is exhausted. She is sick in Varanasi. Along the ghats of Varanasi, Ganga water is polluted. About 95% of this pollution is caused by sewage flowing into the river from the point sources of pollution described above. The level of this pollution can be quantified by biochemical oxygen demand (BOD) in mg/l of the river water, which is a measure of organic matter present in water, and the number of faecal coliform counts (FCC)/100 ml of water sample, indicating the presence of faecal coliform bacteria in water, the root cause of practically all water-borne diseases. The BOD of Ganga water in Asi, at the beginning of the city is around 4 mg/l and FCC/100 ml is around 60,000. The river flows downstream from this point and the quality of Ganga water at the end of the town at the Varuna confluence is poor, with BOD equal to 20 mg/l or more and FCC around 1.5 million/100 ml. The river water at the end of the town is grey and stinks, with methane bubbles coming to the surface. This is a serious matter. The river along the ghats of Varanasi is used culturally, and is used for sipping, drinking and worship in the temples. Ganga's designated use in holy cities like Varanasi cannot be defined by class A, class B or class C rivers. The media and planners these days classify Ganga as class B river for which BOD < 3 mg/l and FCC $< 500/100$ ml. Without accepting it, even if this criterion for the Ganga is quoted for discussion, the river is heavily polluted along the ghats of Varanasi. The condition of the river water in all the big cities (more than five in number) situated along the Ganga is more or less like that of the Ganga in Varanasi. In smaller cities (about 100 in number) the river is polluted, but pollution level is lower than that at Varanasi.

The encouraging or brighter part of this disgusting situation is that the entire 2500 km length of the Ganga is not polluted. Dissolved oxygen level in Ganga water is good and fish can be found in most parts of the river. River water even at the worst polluted places is better in the midstream and also at a distance of several kilometres from the city on its upstream and downstream sides. Thus the whole river is not polluted.

Technically speaking, if point sources discharging pollutants in the river are firmly stopped, 95% of the river pollution will be eliminated. The city's wastewater must be treated appropriately to make it innocuous for reuse in fields and other such places. In today's world and for a river like Ganga in Varanasi this can definitely be done. It is the responsibility of all of us to do this.

The remaining 5% of the river pollution is caused by non-point sources. The society has to be educated and made environmentally conscious to deal with this 5% pollution.

The Sankat Mochan Foundation and its 'Swatcha Ganga' campaign

The aforesaid problem of pollution of Ganga at Varanasi and its solution were carefully examined by a set of teachers from Banaras Hindu University (BHU), Varanasi and citizens of Varanasi committed to the Ganga and the Indian tradition, and who have the necessary technical and scientific knowledge. Initial material support came from the Sankat Mochan Temple established by Goswami Tulsidas, the celebrated saint poet who wrote *Ramacharit Manas*. Legal formalities to create a secular foundation named as Sankat Mochan Foundation (SMF) were completed in 1982, when SMF came into existence. All the aforesaid committed persons became members of SMF. A 'Swatcha Ganga' campaign was launched in the same year. Enthusiasm and optimism were seen in every step of the Foundation. SMF was a tiny organization and it is tiny even today, but the work needed to clean the Ganga was very big – much bigger than the capacity of SMF. The foundation wisely decided to act as a catalytic agent, work with the people and spread the message of 'clean Ganga' and the need for everybody's participation and assistance to accomplish the objective of a clean Ganga. Varanasi was chosen as the place to start work.

SMF's work as a catalytic agent to clean the Ganga comprised of talks at street corner meetings, organizing conferences for women, boatmen, Pandas (priests sitting on the ghats), dance dramas and painting competitions by school children, poets' conferences, etc. All these activities designed to reach out to the society proved effective.

Rajiv Gandhi as Prime Minister of India, in his first address to the nation, urged people to come forward to save Ganga and his government decided to launch Ganga Action Plan (GAP) to clean the river in Varanasi and some other cities. The Indian bureaucracy monopolized the GAP to have control over the abundant funds made available for it. The twin objectives of GAP were to intercept and divert the sewage so that it reaches the sewage treatment plant (STP), and make the effluent of the STP innocuous for use in agriculture and such other activities. The government with its nodal agency implemented GAP in Varanasi between 1986 and 1993. Five sewage pumps were installed to intercept sewage flowing into the river from 30 point sources. Out of the 147 MLD sewage generated in Varanasi only 122 MLD was stopped from flowing into the Ganga and 102.9 MLD was treated in the STPs. However, the STP did not control faecal coliform bacteria. But the government argued with SMF that its GAP was successful. SMF was disappointed, helpless and challenged by such an outrageous statement.

SMF took the challenge. It gathered funds to create the Swatcha Ganga Research Laboratory (SGRL) situated at Tulsi Ghat, which monitored the river water quality every day. The published data of SGRL's monitoring exercise exposed and embarrassed the government. SMF proved that during electrical power failure (which happens every day) and during the five months of the flood season, the sewage pumps did not work and total sewage of the city passed into the river every day. The treated effluent of the STPs was ruining the health of the villagers, their crops and the groundwater. This strategy of SMF in exposing the faults of GAP made the government defensive. The government made proposals to implement GAP Phase II in 1994 and got money sanctioned for its implementation. But in the new plans, the faults of the earlier GAP were not corrected.

Varanasi Nagar Nigam and Sankat Mochan Foundation as public–private partners to clean Ganga

Varanasi Nagar Nigam (VNN), after receiving the powers given to it by the 74th Amendment of the Indian Constitution, decided to prepare its own proposal for GAP Phase II. VNN requested SMF to make this alternative proposal. SMF's team of experts from India and USA made this alternative proposal for GAP Phase II. Details are given later in this article. VNN unanimously accepted this alternative proposal in the form of a project feasibility report (PFR) known as VNN–SMF PFR for GAP Phase II and

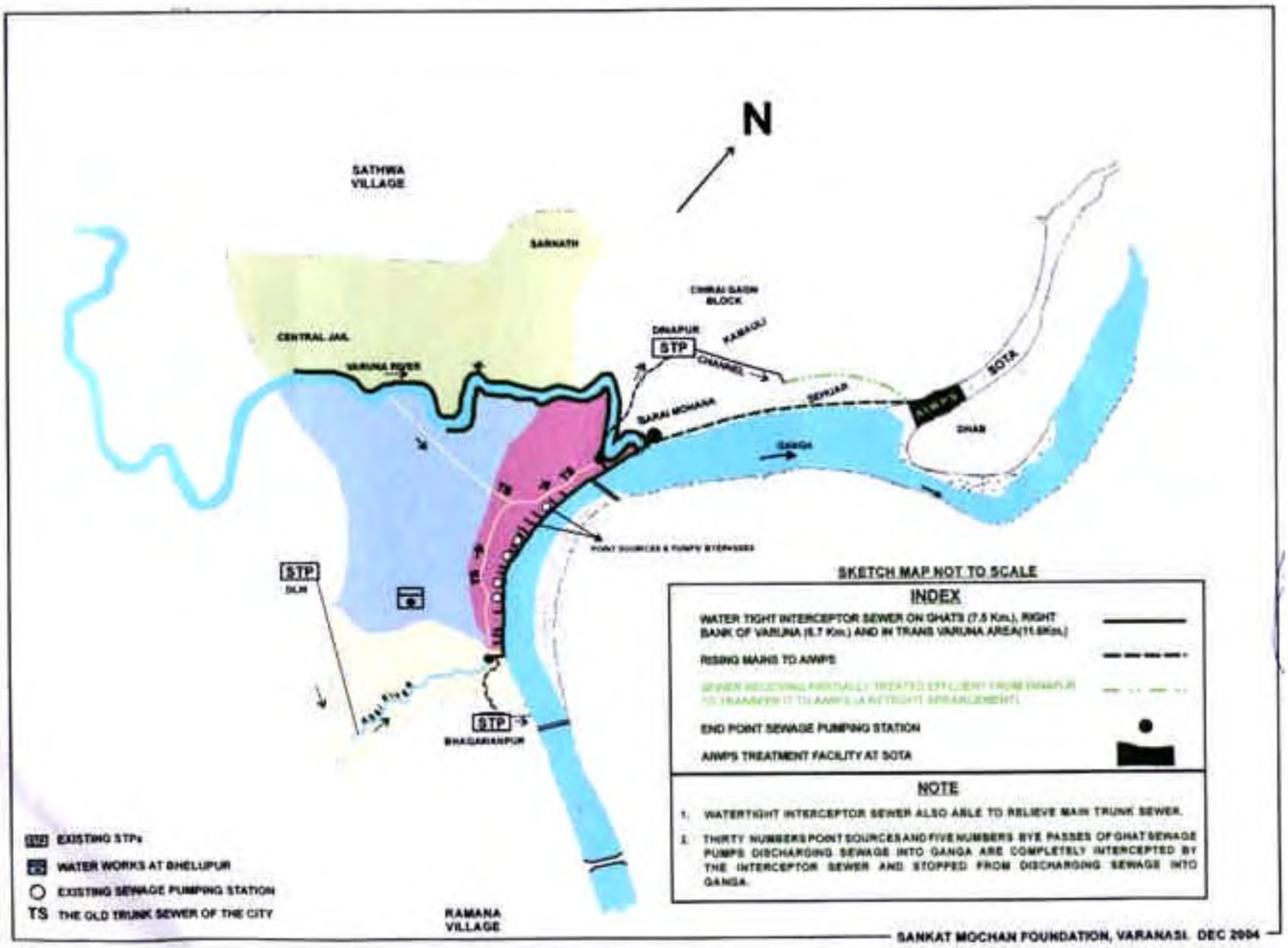


Figure 1. SMF–VNN proposed PFR for GAP phase II at Varanasi.

requested the government to release funds for its implementation. The schematic location of the sewerage system and treatment plant suggested in the proposed PFR is shown in Figure 1 (refs 6, 7).

The VNN–SMF PFR has been appraised by government's experts. Good suggestions coming out of this appraisal exercise were incorporated in the VNN–SMF PFR for GAP Phase II in 1998. But the Government rejected the VNN–SMF PFR and insulted the VNN. About 56 corporators of VNN filed a PIL against this action of the government. Since 1998, the matter is pending in the court of law.

In the meantime, the government insisted that its PFR for GAP Phase II be considered by VNN. However, VNN did not find it suitable for Varanasi. The government's PFR for GAP Phase II has been returned with five objections raised by the VNN.

The government appointed technical committees to examine both the PFRs. These technical committees have given their recommendations in favour of the VNN–SMF PFR. This PFR is less expensive in all respects than the government PFR. The government is not acting on the reports of the committees that have recommended VNN–SMF PFR.

The VNN–SMF PFR has been unanimously accepted by the General Body of the VNN. It meets all the local needs. The work of SMF with VNN is exemplary. A real public–private partnership has done the capacity building of VNN and has stopped the wrong-doings of people in power in matters of GAP Phase II. Other municipal corporations and Nagar Nigams have succumbed to the pressure of the government. They have allowed the government to plan GAP phase II in their cities and implement them. Hundreds of crores of rupees were spent once again in these cities, but the Ganga could not be cleaned. Varanasi is the only city where the Nagar Nigam is struggling for its rights to set up an appropriate system to clean the river and its environment. SMF is drawing every ounce of its energy to support VNN. The struggle continues and Ganga continues to be polluted.

It is hard to believe that prejudices and mindset of the people in power can go to this extent to stop implementation of a proposal, which is technically most appropriate for Varanasi and is most economical and has the support of the people. Constitutional rights of the III Tier of the government (which VNN is today) to decide its plan to clean the Ganga and implement it, have been denied by the government. Supporters of VNN are called 'hounds' and the government's important functionaries have said openly that such NGOs should be driven out of the town. It is a painful experience and the pain becomes acute when we realize that for the same work, SMF received Global 500 Roll of Honour in 1992 at Rio on the occasion of UN's celebrated conference UNCED and the Earth Summit. *Time* magazine during the millennium year nominated SMF's President as one of 'seven heroes of the planet'. In the year 2000 President Clinton invited SMF's President to share the podium with him at Agra, when he (Clinton) gave a public lecture on the environment. He openly praised SMF's work as a unique example of faith and science.

The *New Yorker* magazine has covered our work in right perspective in a ten-page article in 1998, but the media in India has never gone into the details of the work that. SMF is doing for cleaning the Ganga by combining faith and science. An Indian magazine sees this combination of science and faith as weakness of the 'Swatcha Ganga' campaign. It finds religious rites of Hindus in Varanasi and a combination of science and faith as reasons for increasing pollution of Ganga in Varanasi. The World Bank thinks that development and environmental protection cannot be done without combining faith, spiritual approach and science. Ted Turner's UN Foundation found the solution given by SMF for GAP Phase II at Varanasi to be excellent and offered to give full assistance to this project. But the Government of India told UNDP that NGOs could not be encouraged in infrastructure building. The government invites Japan International Cooperation Agency (JICA), Government of Japan to do the job of cleaning the Ganga. JICA finds the work bankable and submits its proposal for giving Japan Bank for International Cooperation's (JBIC's) loan to VNN for implementing the Uttar Pradesh Jal Nigam (UPJN) PFR for GAP Phase II (Figures 2 and 3) (refs 8, 9). JICA has submitted a plan for enhanced taxation on the people of Varanasi to recover its loan. VNN does not accept this. The government dissuades the UNDP to give grant-in-aid for Ganga in Varanasi, but encourages JICA to work on this project to earn profit and tax the people. VNN's chief executive working under the Government of Uttar Pradesh agrees with JICA and does not find himself obligated to carry out VNN's resolution in respect of GAP Phase II. Small financial assistance given by International Development Agencies of governments like Sweden and USA directly to NGOs may also stop, because the Government of India has taken a policy decision that foreign assistance to NGOs may not be given directly. NRIs living outside India want to support gurus, temples and Hindu organizations and they are not so interested in NGO activities going on in India for development and appropriate use of technologies. Big international foundations want NGOs to work in areas, which are favoured by these foundations. Hence SMF is not able to get funds from them also. SMF does not have staff and energy to simultaneously work to generate resources and continue with the pressure struggle.

What should we do? Where shall we go? We know that we are doing right things and working with commitment to clean the Ganga and using all our technical skills and energy to achieve the goal of a clean Ganga. This story needs exposure at the widest level. We started working when our hair was black and we are still working for a clean Ganga at Varanasi when our hair has greyed. No tangible results so far. We are not going to be deterred

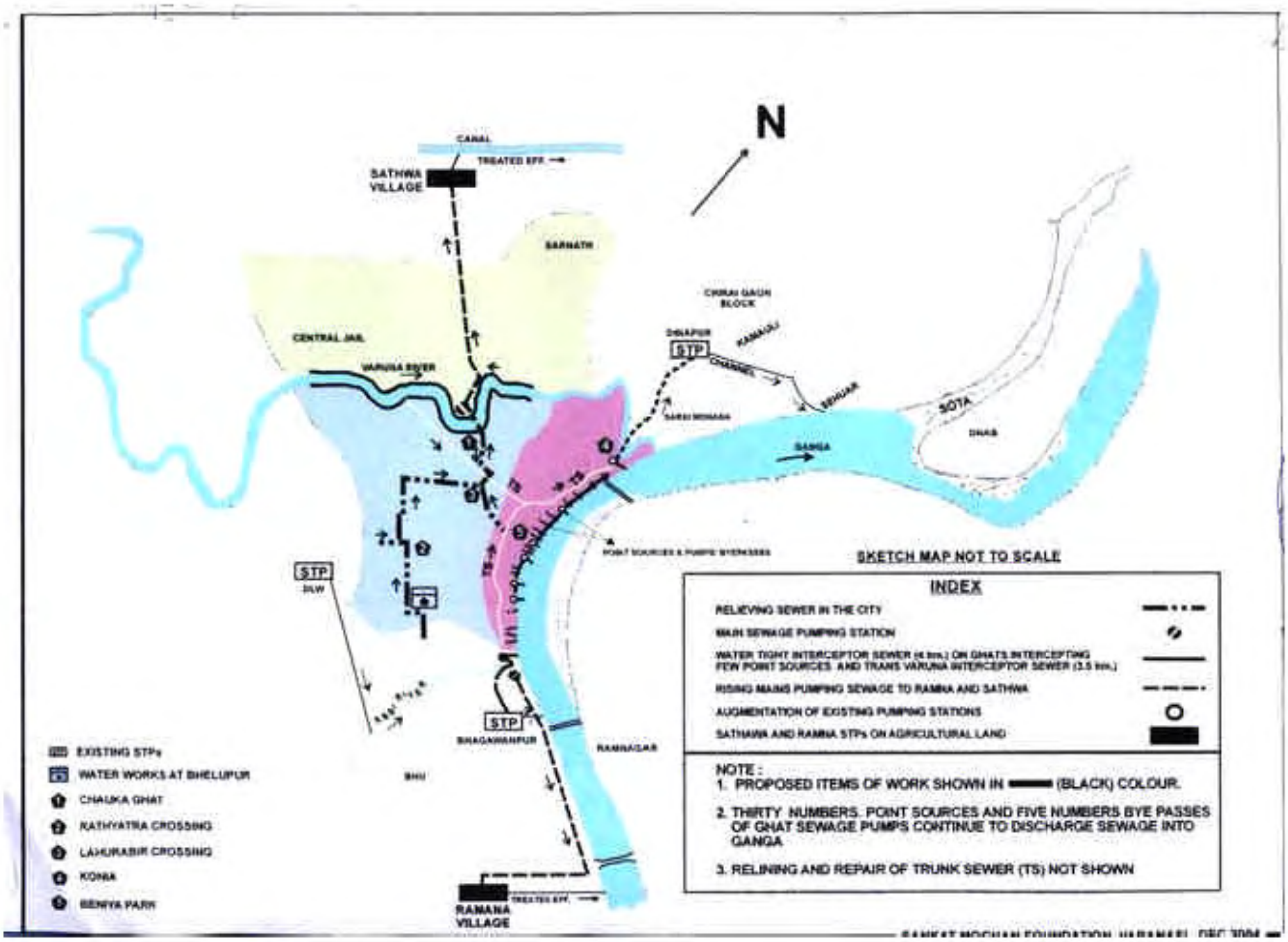


Figure 2. PFR for GAP phase II in Varanasi proposed by UPJN.

from the path we have chosen to clean the Ganga at Varanasi. We have the same enthusiasm, which we had in 1982. Hope this travail will come to a happy end when appropriate infrastructure to clean the river is put in place and the river gets cleaned. The example thus set in Varanasi will inspire other river cities to take care of the river in their own territory.

The technical solution

The failure of the system created in Varanasi by the government between 1986 and 1993 under the GAP Phase I, non-availability of electrical power and the need to have a most economical alternative prompted SMF to search for suitable site-specific solution for interception and diversion and treatment. The basis of the proposal prepared by SMF for GAP Phase II for Varanasi was the following:

(i) Interception and diversion of sewage flowing into the Ganga on the ghats to be done without using electric power and pumps.
(ii) The treatment plant for Varanasi to use the least amount of electric power and a technology which ensures elimination of faecal coliform and other harmful bacteria and to be low in operational and maintenance costs.
(iii) Retrofitting of the existing pumps and STP to ensure use of GAP Phase I facilities.

The proposed technical solution for prevention of pollution of river Ganga at Varanasi has the following features:

(i) Watertight interceptor sewer along the ghats of the Ganga between the last line of buildings and the river. This will collect the sewage from all 30 ghat-front wastewater point sources and convey the same by gravity to a treatment plant.
(ii) Two interceptor sewers along the two banks of river Varuna, conveying the collected sewage to the treatment plant.
(iii) Advanced Integrated Wastewater Oxidation Pond System (AIWPS), developed at the University of California at Berkeley, USA, of 300 MLD capacity at the sandbar known as Sota, about 8 km downstream of the city (Figure 1).

For the interceptor sewers, proper care has been taken to ensure their stability against uplift pressure during floods. The gradient and size of the interceptor sewers have been designed to ensure flushing velocity. Their alignment will be along the pathway existing between buildings on the ghats and the river.

Search for an appropriate site for the treatment plant

A wasteland called Sota about 8 km downstream of Varanasi city and situated a few kilometres away from the main valley of the river, was selected for a treatment plant on the basis of reconnaissance survey of the area. It does not belong to the cultivators and can be used without paying any compensation charges required in the acquisition of land. The entire area of the wasteland (500 m × 14 km) is about 10 m above the river bed, but is flooded by the river every year for about 45 days. It carries 3–6% of the flood discharge. Using Sota for making ponds will stop this flood discharge and would direct it to the main channel. Closing Sota for making the ponds would create an afflux of 10 cm at the site during record floods, and the effect of this afflux gradually fades about 40 km upstream of Sota. The question before SMF was whether the closure of Sota would change the regime and course of the river and start heavy erosion and silting in the river.

James W. Kirchner from University of California at Berkeley, USA and some faculty members of BHU along with SMF staff surveyed the 40 km stretch of the river likely to be affected by closure of Sota. The aforesaid apprehension of scour, erosion and change of river course may not occur on the linear timescale. Physical modelling of the whole stretch of the river and of the timescale is not possible. Hence an appropriate simple mathematical modelling was done and in any case, such a model would give more dependable result than a physical model[10].

The result of the mathematical model confirmed that closing Sota for the treatment plant may deepen the bed of the river by about 0.4 m, which is comparable with the size of bed bards formed in the river every year. The course of the river will not change. Bank erosion rate may increase by 3–6% of the present rate. It may be noted that the river is in the alluvial plain and does not have a firm bank or bed. Little erosion or deposition goes on. Closing Sota for ponds will not affect this process substantially to cause any alarm. The decision to choose Sota for the treatment plant was taken based on this scientific study.

The treatment technology – AIWPS

The sewage treatment plant proposed in SMF–VNN PFR uses AIWPS technology designed by W. Oswald and his associate Bailey Green at UC, Berkley, USA (Figure 4). Almost 50 years of effort by Oswald and his team has resulted in the development of ecologically efficient natural system for wastewater treatment and water reclamation. Their scientific study has been based on research involving physical, chemical and microbiological laboratory, pilot plant and field study and has established the most efficient way to use solar energy for algal photosynthetic oxygen release from the supporting water and discovering the special design requirements to foster in pond methane formation, so efficient that it virtually eliminates the costly sludge removal required for any waste stabilization pond system[1–5].

This technology has been successfully used at many places in California and elsewhere. The AIWPS is a series of four ponds and first of this series is called ‘advance facultative pond’ (AFP). The next pond in series is called the ‘high rate pond’ (HRP). The third pond is knows as ‘algal settling pond’ (ASP) (Figure 4). The AIWPS facility proposed at Varanasi to suit the shape of the land available and the quantity of the sewage to be handled is shown in Figure 5. Number of modules depends upon the quantity of the sewage. For maximum efficiency, each module should not handle more than 50 MLD of wastewater. The treated water goes to the ‘maturation pond’ (MP) provided to remove the faecal coliform bacteria. The wastewater is screened and degritted before it is allowed to go through the AIWPS.

The advance facultative pond

- The AFP has large area which prevents intrusion of oxygen to ensure stable fermentation in the deep fermentation pit located at its bottom.
- The fermentation pit is in complete anaerobic condition, capable of fermenting all the organic material other than refractory material and thus leaving no residue in the form of sludge.
- The fermentation pit removes all settleable solids and 60% of BOD. About 20% of BOD is removed in the top layer of AFPs.
- Settleable solids in the fermentation pit undergo anaerobic decay to produce methane and soluble acids.
- In the fermentation pit, organic nitrogen is converted into nitrogen gas.
- The fermentation pit retains parasitic Helminth ova and heavy metals. Various chlorinated hydrocarbons (pesticides) also undergo biodegradation to some extent in the fermentation pit.
- The large column of water in the AFPs purifies methane to 85–88%. Methane is collected in the submerged gas collectors.
- Greenhouse gas emission is minimized and CO_2 generated during fermentation and electricity generation is absorbed in AFPs.

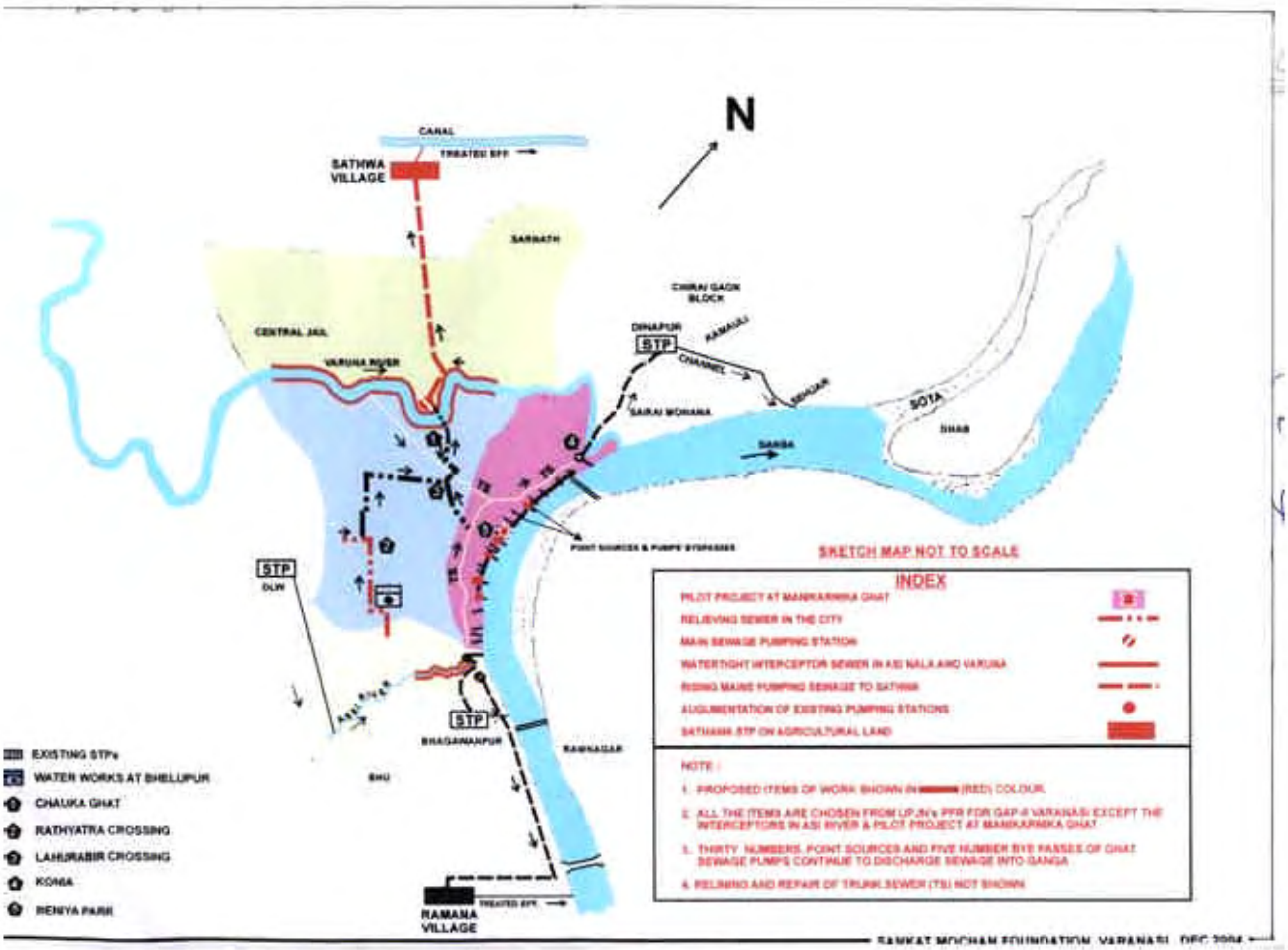


Figure 3. Water quality management plan for Ganga in Varanasi by JICA.

The high rate pond: The specific features of HRP are:

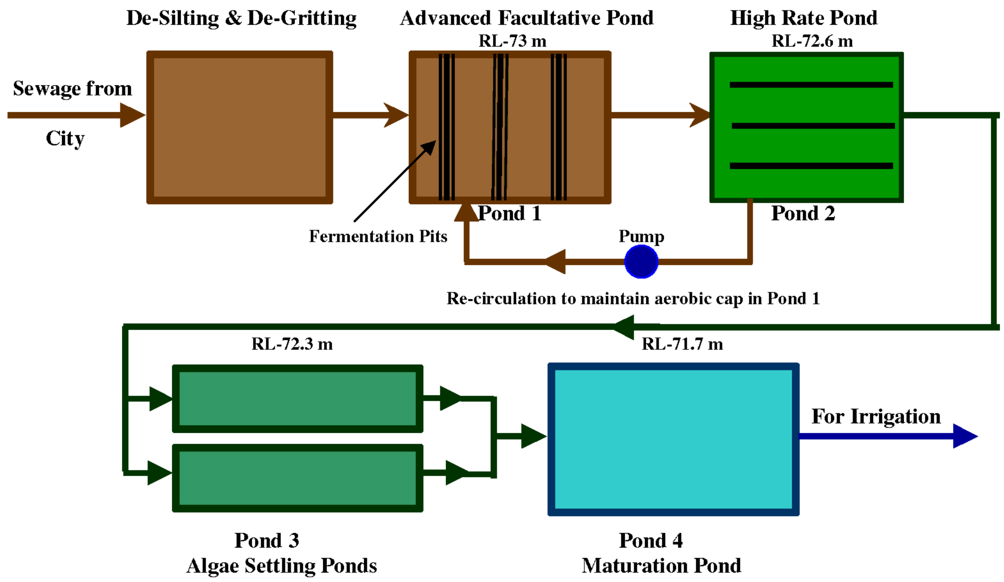
- HRP is endless, gently paddle-wheel mixed, raceway designed to grow crop of algae and to release a maximum amount of free molecular oxygen in dissolved state (DO) to the surrounding water under controlled conditions.
- Idealized photosynthetic equation is:
  $CO_2 + 2\,H_2O \Rightarrow (CH_2O) + O_2 + H_2O$
  $(CH_2O)_x$ typifies the organic matter in the plant material.
- Abundant supply of oxygen is ensured if sufficient light, moderate temperature, time and nutrients are present to foster algal growth. About 2% of the intensity of full sun is sufficient for maximum growth rate. Hydraulic mixing ensures it.
- Analysis of algal cell gives 52.4% carbon, 7.4% hydrogen, 29.7% oxygen, 9.2% nitrogen and 1.3% phosphorus on an ash-free-dry-weight basis.

The stoichiometric formula for algal cell is $C_{106}H_{181}O_{45}N_{16}P$. When this is generated by photosynthetic process, O_2 is released at a rate 1.55 times the dry weight of algae produced.

- Photosynthetic oxygen generated in HRP raises DO level reaching super saturation level of 20 to 30 mg/l. A DO cap on AFP oxidizes H_2S or PH_3, and seeds the AFP with algae adopted sewage composition.
- pH on top may increase to 9. Bacteria growing in lumps go to the bottom in neutral pH zone
- DO released could be a short-lived radical acting as a disinfectant.
- DO in soluble form goes to bacteria which break down organic waste.
- Due to high pH levels in HRP, calcium and magnesium present in the sewage are precipitated.

The algal settling pond

- ASPs are designed to be as quiescent as possible in order to permit sedimentation of the heavier algal species grown in HRP.
- ASPs are designed in pair, to permit algal removal either by drawing in pond or by pumping them to under-



POND	CUMULATIVE POLLUTION REMOVAL
POND-1	BOD- 80 % FCC- 1 Log TOTAL METHANE FERMENTATION OF ORGANIC MATTER LEAVING NO SLUDGE
POND-2	BOD- 85 % FCC- 2 Log NUTRIENTS & INORGANIC MATTER IS ASSIMILATED BY MICRO ALGAE
POND-3	BOD- 90 % FCC- 3 Log
POND-4	BOD- 95TO 99 % FCC- 4 TO 5 Log

Figure 4. Schematic representation of AIWPS facility process. The AIWPS facility comprises of ponds 1–4 placed in series. The sewage flows by gravity from one pond to the other. After desilting and degritting, the sewage enters 7 m deep Pond 1 through methane fermentation pits placed at the bottom and rises slowly in complete anaerobic condition. It flows to shallow Pond 2 between channel dividers in aerobic condition caused by micro-algae generating oxygen by photosynthesis. The total electrical energy consumption in this process is 0–100/100–200 kWh per ml depending upon methane recovery/no methane recovery and is much less than other conventional sewage treatment technologies. The wastewater along with micro-algae flows alternatively to one of the twin Ponds 3. One of the twin ponds empties into Pond-4 after the algae in it settle down and are removed from the bottom. The other twin receives discharge from Pond 2. Clean water good for fish culture/irrigation having faecal coliform bacteria in hundreds only and BOD less than 10 mg/l results in Pond 4. AIWPS facility is running successfully at several places in USA for decades and is good for the tropical climate.

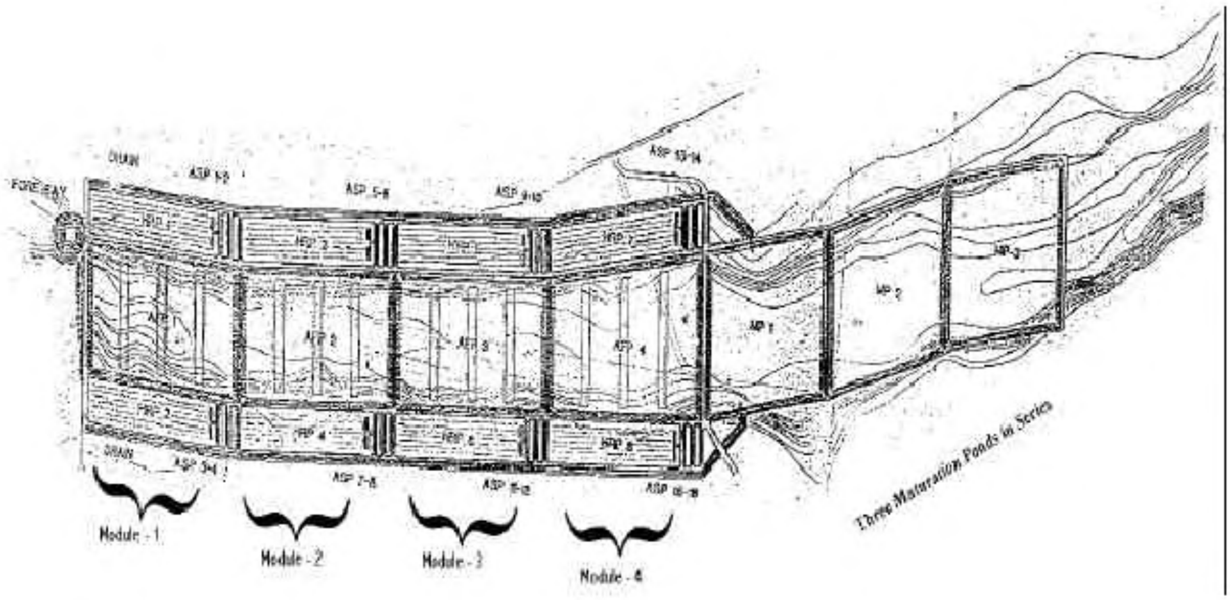


Figure 5. Schematic map of AIWPS facility proposed at Sota showing four modules in parallel and three maturation ponds in series. AFP, Advanced facultative pond; HRP, High rate pond; ASP, Algal settling pond and MP, Maturation pond.

drained drying beds. Unless there are suspended solids, it is not necessary to remove algae from pond effluents. They can be used as excellent fish food when they diluted to maximum DO at a level good for respiration of fish and algae itself. Algae have fertilizing value.

Maturation pond

- MPs may be simple holding ponds for ASP effluents. Ten to twelve days holding provides sufficient disinfection for safe surface irrigation.

- They are designed for residual disinfection. If the system has been correctly designed, water in MP is stable enough to grow catfish, carp, etc. Water from MP should have a faecal coliform concentration less than 1000 per 100 ml, WHO's guideline for irrigation of crops not eaten raw. Since microalgae are rich in nitrogen, phosphorus and potassium, the major components of good fertilizer, these are important yield benefits in irrigating crops with water containing process algae.

Advanced treatment and water reclamation

If unrestricted use of wastewater is required, then dissolved air floatation followed by sand filtration and ultraviolet (UV) disinfection have to be done to achieve faecal coliform of 2.2 per 100 ml or less. This increases the cost but it is less than the cost which has to be incurred on a traditional tertiary treatment to achieve the aforesaid results. UV disinfection or reverse osmosis could also be used[11–15].

Concluding remarks

The resurgence of India in the modern times has become phenomenal which the world is experiencing today. In this process, culture, science and technology (S&T), political process and the people must interact for balanced development of the country. We need to inculcate scientific outlook in the masses. S&T needs to appreciate the finer elements and fundamentals of our culture. Our universities and professional bodies have to take the lead, be it cleaning of rivers, environment or other spheres, affecting one billion people living in this country. A good beginning could be made by cleaning Ganga at Varanasi, using appropriate technology with minimum cost and by involving people. It will be inspiring and rewarding for the nation to clean river Ganga.

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