Slow Sand Filtration Project

MEETING OF REPRESENTATIVES OF
SSF-PROJECT COUNTRIES

NAGPUR, INDIA - SEPTEMBER 15-19, 1980

International Reference
Centre for Community
Water Supply and
Sanitation

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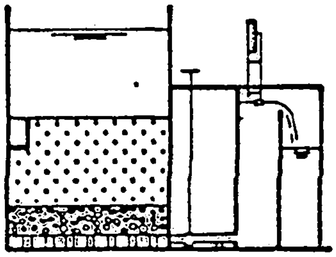

National Environmental
Engineering Research
Institute

Nehru Marg,
NAGPUR - 440 020
India

STATUS REPORT ON
SLOW SAND FILTRATION PROJECT
IN COLOMBIA

prepared by: Mr. Carlos Humberto Peralta,
Mr. Mario Santacruz.

August, 1980.

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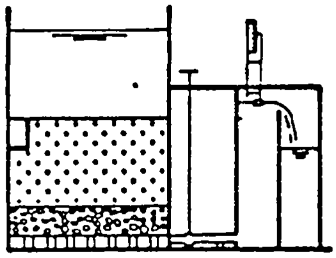

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SLOW SAND FILTRATION PROJECT
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COUNTRY REPORT I

BY

NATIONAL INSTITUTE OF HEALTH

MINISTRY OF HEALTH

COLOMBIA

1. INTRODUCUCTION

Under an agreement between the International Reference Centre for Community Water Supply and Sanitation and the National Institute of Health of Colombia the latter has since November 1978 been involved in an integrated Research and Demonstration Project on Slow Sand Filtration.

Two Villages were selected for the construction of the Slow Sand Filtration demonstration plants:
Alto de los Idolos and Puerto Asis.

2. VILLAGE DEMONSTRATION PLANT No. 1

Name of Village	:	ALTO DE LOS IDOLOS
Municipality	:	ISNOS
Department	:	HUILA

2.1. General Information

The village is located 6 kilometers from San Jose town, the capital of that Municipality. The place is an archeological centre of the San Agustin indians culture. The population is scattered throughout the area, each house possessing a small plot of land for farming. More-over, the site is an important tourist attraction that is greatly benefited by this project.

2.2. Design of the water supply.

2.2.1 Population

In 1978	:	1.160	inhabitants
In 1998	:	1.700	"
For Design:		1.700	"

2.2.2 Per capita supply : 168 liter per capita per day (average)

2.2.3 Source of Raw Water : Guadualito Creek

2.2.4 Turbidity : Maximum : 30 p.p.m.
Minimum : 1.5 p.p.m.

2.2.5 Flow sheet. (annex 1, 2)

a. Raw water intake : Submerged type concrete structure.

b. Pipe line from intake to plain sedimentation tank :
21 m. Long, 150 mm. O PVC type R.D.E. 41.

c. Plain sedimentation tank : Rectangular reinforced concrete 0.90 m. wide, 3.60 m. long, 1.50 m. deep.

d. Pipe line from plain sedimentation tank to slow sand filters:
620 m. long, 100 m.m. O P.V.C. tupe R.D.E.41.

e. Slow Sand Filters : Two square units 6.30 m. each side, surface area 40 cm. each, reinforced concrete.

e.1. Internal depth of the box :

Free board above supernatant water level:	0.20 m
Supernatant water	: 1.10 m
Filter medium	: 0.70 m
Four layer gravel support	: 0.30 m
TOTAL	2.30 m

e.2. Drains : Perforated Asbest-Cement pipes 150 mms.

e.3. Rate of Filtration : 0.2 m/hour.

e.4. Filter Operation :
This type of filter has two alternatives as far as the direction of the flow of the water is concerned. Initially the inlet will be at the bottom through the six pipes which are called "drainage pipes" and the outlet is at the top. If, after a few months of operation, the results of the monitoring show that the quality of the produced water is not satisfactory it is planned to reverse the flow of the water of one of the filters. In that way the

efficiency and ease of operation and maintenance between an up-flow and down-flow filter can be compared under identical circumstances.

The cleaning for the second alternative (flow from the bottom to the top) is done by draining off the water from the filter with the inlet valve closed. The cleaning for the second alternative (flow from the top to the bottom) will be done by draining off the water from the filter until 5 centimeters below the top layer of the sand and scraping off the sand for approximately 3 centimeters.

f. Clear Well :
Rectangular reinforced tank 80 cubic meters capacity.

g. Distribution System :
The distribution system consists of 21 kilometers of 75 mm, 50 mm. 25 mm. P.V.C. pipe with 173 house connctions and 3 public school connections.

2.3. Construction.

The water supply without the slow sand filters was built in 1978 with an active community participation of Colombian pesos 711.290 from the total of 2.895.496. In other words, the share of the community was 24.6% of the total.

The slow sand filters were built from March to September of 1979. The only real problem was that the contractor for the skilled labour died from a heart attack and this caused a delay of two months in order to solve the legal issues which arose due to this event. However, the fact that the sand for the filterbeds had to be carried 380 kilometers by truck from El Guamo town, was obviously another constraint. Percentagewise, the financial commitment of the community towards the construction of the Slow Sand Filters was greater than at the time that the water supply system was built.

CONSTRUCTION COST OF S.S. FILTERS

Source	Colombian $	U.S. $	%
I.R.C	465.737	11.089	52.8
National Inst. of health	153.329	3.651	17.4
Community	263.250	6.267	29.8
TOTAL	882.316	21.007	100.00

This table does not include the cost of designing of the slow sand filter. The filtration plant was designed by engineer Jamie Ortiz who belongs to the Construction section of the National Institute.

2.4. Performance Evaluation

A systematic monitoring programme has been undertaken by the Huila Branch of the Rural Basic Sanitation Division and the Huila Health Service for each of the two units.

The parameters for performance besides the weather conditions and temperature are:

A. pH
B. Turbidity
C. Colour
D. Bacteriological quality (MPN test)
E. Residual Chlorine
F. Iron

The water samples to be collected and the analysis to be done are:

Samples to be collected	Analysis
At plain sedimentation tank inlet	A-B-C-F
At filters inlet	A-B-C-D-F
At filter outlet of unit 1	A-B-C-D-F
At filter outlet of unit 2	A-B-C-D-F
At the Chlorination point	E
At the tap in a house connection	D-E

The physico-chemical monitoring started in April of 1980. The samples are collected once a week by the Huila Branch of the Basic Sanitation Division. By July 15, nine sets of samples have been analysed in a Hach field test kit giving the following results:

2.4.1. The pH had the same value in all the samples collected on one day. For the future, therefore, this parameter will only be analysed in one sample.

2.4.2. Reduction of colour

The plain sedimentation tank is very efficient to reduce colour. The average at the inlet of that tank was 15.8 units and the average at the inlet of the filters was 0.28 units. The efficiency of the filters for this purpose was very low because the average colour at their outlet was 0.26.

2.4.3. Turbidity.

The average turbidity at the inlet of the plain sedimentation tank was 14.0 NTU at the inlet of the filters 10.1 NTU and at the outlet of the filters was 4.2 NTU.

2.4.4. Iron.

The average iron content was 0.42 mg/l at the plain sedimentation tank inlet, 0.31 mg/l at the filter inlet and 0.24 mg/l at the filter outlet.

2.4.5. Reduction of bacteriological pollution.

The bacteriological monitoring started in November of 1979. The samples were collected by the Huila Branch of the R.B.S. Division and were analysed at the Neiva laboratory of the Huila Health Service with the following results: The M.P.N. index of E. Coli content as measured at the inlet of the filters showed a hight faecal coliform count in the raw water.

Although the efficiency of the filters was more than 80% in reducing the M.P.N. index of E. Coli content in 3 out of the 4 samples collected, the bacteriological quality is not satisfactory. Three possible reasons are:

- The layer of sand is too thin.
- The sand is fairly coarse. (E.S. 0.34 mm U.C. 2.3).
- The wind is blowing dirt on the filters because they are not covered and since the actual direction of the flow is from the bottom to the top it means that the filtered water is exposed to that dirt to a large extent.

2.5. Disinfection.

The chlorine dosing equipment is located at the outlet of the filters. It consists of a 25o lt. asbestos-cement container which serves as a floating-platform hypochlorinator. 2 mg. per liter of available chlorare added to reach a residual chlorine content of 0.2 mg./ liter. The operator checks this dose by counting the number of drops that the plastic tube delivers in a minute.

2.6. Future Activities.

Evaluation of the performance of this plant during the first four months of monitoring made it necessary to make adjustments to the filters in order to improve the quality of the effluent. By August 1st, the following steps were undertaken:

2.6.1. To investigate Guadualito Creek upstream from the intake to locate the sources of pollution which are causing the high E. Coli content of the raw water.

2.6.2. To reduce the filtration rate to 0.15 m/h and collect three sets of samples at monthly intervals.

2.6.3. To increase the thickness of the filter bed to 0.90 m.

2.6.4. To change the direction of flow in filter from No. 2 (from the top to the bottom).

2.6.5. To cover filter No. 1 leaving the actual direction of flow (from the bottom to the top) in order to compare results with filter No. 2.

2.6.6. Also to collect 3 samples for bacteriological analysis at the plain sedimentation tank inlet to check its efficiency as far as the improvement of the raw water bacteriological quality is concerned. Since this tank has a reinforced concrete cover no repollution can occur. The monitoring will continue for each of the two filters until the end of 1980 in order to compare the results with the experiences of the first four months. By the beginning of 1981, the necessary adjustments will be undertaken in the plant taking into account all the experiences gained by monitoring the performance of the filters.

3. Village Demonstration Plant No. 2.

Name of the village : Puerto Asis.
Municipality : Puerto Asis.
Department : Putumayo.

3.1. General Information.

Puerto Asis presents a special case. It is the only village of its size in the Department of Putumayo that at present is not serviced by an adequate watersupply. The water for this village is still being transported with mule carts which carry the water in barrels from the river or privately owned shallow wells to the consumers.

The construction of the water supply is managed by the National Institute of Health in spite of the fact that Puerto Asis is larger than those villages normally considered rural by the National Rural Basic Sanitation Programme. This is due to the fact that the community, the municipality and the departmental government requested the intervention of the institute from the National Government in order to guarantee successful completion of the project.
In the beginning (1976) a treatment plant was considered that included rapid and slow mixing, flocculation, sedimentation, rapid filtration and chlorination. From the engineering point of view, the plan was very good but the cost of construction, operation and maintenance would have been very high. However, since the Putumayo district is one of the poorest regions of Colombia, the population would not be able to afford such an expensive system.
Taking into account the low turbidity of the raw water, a simplified water treatment plant, including slow sand filters, was designed in 1978 to solve the major problem of the population of Puerto Asis.

3.2 Design of the water supply

3.2.1. Population.

In 1978 : 14.100 inhabitants.
In 1988 : 18.000 inhabitants.
In 2000 : 24.300 inhabitants.

Design population for the first stage of construction (for slow sand filters and pumping equipment) : 18.000 inhabitants. Design population for intake, pumping stations, aerator, plain sedimentation tank, clear well : 24.300 inhabitants.

3.2.2. Per capita supply : 184 litres per day.

3.2.3. Source of Raw Water : Negra Creek.

3.2.4. Turbidity : Maximum : 13.2 p.p.m.
Minimum : 7.0 p.p.m.

3.2.5. Flow Sheet. (see annex 3, 4)

a. Raw water intake : Lateral reinforced concrete structure.

b. Raw water pumping station :
2 of 47.5 litres per second 13 meters of head. deep well type Centrifugal pumps and Diesel engine. (One standby). Reinforced concrete and brick masonry building.

c. Aeration :
Trickling beds of cokes, four beds.

d. Plain sedimentation :
2 rectangular tanks: 23 meters long,
3.0 wide and 2.50 deep reinforced concrete and brick masonry.

e. Slow Sand Filters :
3 rectangular, 6 meters wide 23 meters long, reinforced concrete and brick masonry.

INTERNAL DEPTH OF THE BOX :

Free board above supernatant water level	0.20 m
Supernatant water	1.00 m
Filter medium (initially)	1.00 m
Four layer gravel support	0.50 m
TOTAL	2.70 m

Main drain : 250 mm wide concrete channel
Lateral drains 50 mm P.V.C. pipes.

FILTER MEDIUM SPECIFICATIONS

To select the sand for the filter medium five samples were collected on different riverbeds located around Puerto Asis and analysed for organic content and grain size distribution at the Pasto branch of the Mining Institute. The best available sand was at the Putumayo river bed located two kilometers from the treatment plant, however this had to be screened in order to remove the coarser material.

The prepared sand gave an effective size of 0.23 mm and a uniformity coefficient of 2.5 No. organic content was found.

Design rate of filtration : 0.4 m/hour.

f. Clear Well :

Rectangular reinforced concrete 210 cubic meters capacity.

g. Post Chlorination :

Manual control, chlorinatorsolution-fed type.

h. Drinking water distribution pumping stn.

2 of 46 litres per second 27 meters of head centrifugal pumps and Diesel Engine (one standby), reinforced concrete and brick masonry building.

i. Elevated storage tank :

Reinforced concrete 500 cubic meters capacity additional to the existing one with a capacity of 192 cubic meters.

j. Distribution system :

28.8 kilometers of 250, 200, 150 mm asbestcement pipes and 100,75 and 50 mm P.V.C. pipes.

3.3 Construction.

Some difficulties were encountered with the siting of the plant. During the rainy season, the village is subject to severe flooding as the water level of Putumayo river may rise by 5.5 m. It was therefore quite hard to find a site which remained above flood level all year round.

Soil investigations showed that the quality of the soil was very poor. The construction of the intake suffered quite some delay since the low strength of the soil required piles for the foundations. Equipment for hammering the piles was however, not locally available. Eventually a solution was found when an oil company which was prospecting in a nearby district was willing to assist.

The construction of the water supply also suffered major setbacks due to financial infrastructural problems. The intake, the raw water pumping station, and the distribution system are 100% finished.
The plain sedimentation tanks are 95% finished.
The Institute already awarded the pumping equipment through a national level public bid at a total cost of 2.295.903 in Colombian currency.
The structures and underdrains of the slow sand filters are 100% finished, all the gravel and filter material is stored on site. The preparation and placing of the gravel and sand has started on July 15th, 1980. A tender will be awarded shortly for three butterfly valves.
In 1980 the financial resources for the construction of the clear well (10% finished), drinking water pumping station, chlorinator and the aereator were obtained from the following sources : Intendencies and Comisarias Administrative Agency, Colombian Ecuadorian Integration Programme and I.R.C.
If the funds arrive in Putumayo in time the water supply will be ready by January 1981. The elevated storage tank will be constructed as soon as additional funds are available. Since the storage tank, due to the weak soil, requires a very expensive foundation, it cannot be accommodated within the current budget.
The total construction cost of the system by June 30th of 1980 was $13.286.516 in Columbian money, including the pumping equipment. $8.388.056 were obtained from Departmental Government and Municipality sources (63% from the total).
The cost of the slow sand filters until June 30 was as follows:

SOURCE	COLOMBIAN PESOS	U.S. $	%
I.R.C	1.080.981	25.737	66
Putumayo Intendencia	293.625	6.991	18
National Inst. of health	220.400	5.248	13
Puerto Asis Municipality	51.600	1.229	3
TOTAL	1.646.606	39.205	100

4. ALTO DE LOS IDOLOS

4.1. Baseline Health Survey.

With the active participation of the Huila Health Service, a research programme was executed on the prevalence and magnitude of the infectious water related diseases together with an opinion survey on the need and value of the water supply.

The Huila Health Service chose the longitudinal approach as the experimental design.

This is a summary of the results from the survey accomplished before the construction of the filters :

4.1.1. 400 samples of faeçes were collected for coprological examination, to discover whether the individuals were excreting protozoa or helminths, at the laboratory of the Pitalito hospital located one hour by car from the village.

These were the results :

Number of families taken into account	172
Number of Coprological examinations	400
Positive results	393
Percentage of positive results over the total	98%
Negative results	7
Percentage of negative results over the total	2%

The prevalence of protozoas and helmiths for these 393 affected persons was as follows.

PARASITES	PROTOZOAS				HELMINTHS		
	E.Histo-lytica.	E.Coli	Giardia Lamblia	Tricho-monas	Ascaris	Tricose-falos	Unci - rias
Number of affected persons	256	219	81	2	286	231	44

From the table the presence of different types of parasites in the same persons becomes evident.

For the different groups according to the age of the affected

A G E	Total of affected persons.	Total of persons according to the type of parasite	
		Protozoz	Helminth
Under 1 year	15	10	11
1 - 4	57	49	42
5 - 14	125	101	111
15 - 44	137	104	115
45 - 59	38	30	32
60 or more	21	18	16
TOTAL	393	322	327

Curative services were provided to the affected persons but only 67% accepted the drugs which were donated by some laboratories.

4.1.2. The opinion survey on the need and value of the water supply was accomplished by questionnaire. There were 162 persons interviewed, one for each family. The results were as follows:

For the question "Do you consider the construction of the water supply useful?" The answers were : 159 for "yes" 1 for "No" and 2 for "I don't know".

For the question "WHY?", in which the interview can choose from seven previously written answers, the results were:

ANSWERS	YES	NO
1 Improves health	17	
2 Time and work savings	130	
3 Improves hygiene	11	
4 Does not improve health	-	
5 Service too expensive	-	
6 Improves the value of the property	-	
7 Cost of the connection too expensive		1

It is important to realize that the majority considered the water supply useful for "time and work savings" instead of "Improving health". This situation has an easy explanation if one considers the community education approach, which the Basic Rural Sanitation Programme formulates when the design of a water supply, like in the case of Alto de los Idolos, does not have water treatment provisions included because there are no funds available to build it. Such a case, the Institute's promoter does not mention to the community the health benefits of the water supply until the funds for the treatment system are available.
As a matter of fact, the Rural Basic Sanitation Programme in Colombia, which deals with the construction of water supplies for small towns with a population under 2.500, decided to build as many water supplies as possible with the available budget. This first stage is followed by a second in which the existing system is receiving priority. That second stage is now gradually beginning.

4.1.3. The second stage of the Health Survey
will be executed when the adjustments which have been indicated under 2.6 of this report have been implemented and have shown to improve the performance of the filters.

4.2. Community Education and Participation.

As far as Alto de los Idolos project is concerned the CEP approach was the same as the normal promotion procedure for the National Rural Basic Sanitation Programme. The methodology that was used once the locality was selected for the construction of the demonstration plant can be divided into five stages.

Stage 1 was a study of the community to draw up an inventory of the sanitary, economic, social and cultural aspects involved. Preliminary sanitary studies were made to obtain overall data as to the technical feasibility of the undertaking. In this case, the quality of the water and the proper site to build the plant. It was felt necessary to also assess the importance the people attached to the construction of water treatment system.

Stage 2 was the project preparation by a Programme Engineer and included a topographic survey, plans and specifications.

Stage 3 comprised the motivation, promotion and organization of the community by a development worker (or Promotor), contacting incluential local groups and authorities, meeting with residents and the community action board. This culminated in the formal signing of the contract between the National Institute of Health and the community for the construction and financing of the Slow Sand Filtration plant and the arrangements for local, government and IRC contributions as well as the administrative responsibilities once the system would be completed..

Stage 4 was the construction itself. Throughout the construction period a community development worker made frequent visits to the village, organized the community for its participation and kept up interest by means of meetings and personal talks. An engineer was responsible for verifying compliance with technical requirements of the construction.
The Rural Basic Sanitation Programme set the amount required from community participation and divided this by the number of households to be benefited. The average contribution per household was the equivalent of 10 days labour.

Stage 5 took place after construction was completed and comprised the administration by the community and supervision by the management board. It started with the handing over of the system to the users at which time the responsibility for operation and maintenance was formally delegated to the existing management board, democratically elected by the general meeting of the users when the original water supply was ready in 1978.
This autonomous board collects the perhousehold charges, appoints board employees (the local operator), makes loan repayments, and ensures operations and maintenance of the water supply as a whole (including the new filters).
A community development worker is always appointed as a member of the Board and is required to visit the community and provide assistance on a regular basis. In this case he visits the village once a week for monitoring purposes besides his regular tasks.
The National Rural Basic Sanitation Programme indefinitely continues to provide guidance and advice to the organization and operation of the system. By the end of 1979, the National Basic Sanitation Programme had oganized 1703 Management Boards responsible for 164.551 house connections as far as water supply is concerned.
For the community health education, information about water, use and conservation was provided at the local schools using the National Rural Basic Sanitation Programme materials and community teachers. The instruction provided at the general meetings emphasized that community development is for individual and group well-being and that the rights and capabilities to participate in each step of the future are their responsibility.

5. PUERTO ASIS.

5.1. BASELINE HEALTH SURVEY.

A socio economic study of Puerto Asis Municipality was made in 1979 by Mr. Hernan Echeverry, an Institutes' promoter. That study included a morbility and mortality index prepared by using existing records at the Puerto Asis hospital. This preliminary study will be implemented by the Putumayo Health Service in a similar way as was done in Alto de los Idolos.

5.2. COMMUNITY EDUCATION AND PARTICIPATION IN COLOMBIA.

As a general experience, the community participation in a small village is better than in a large community and much better than in a capital of a Municipality. On the other hand, participation also depends on the socio-economic aspects of every region. According to Mr Echeverry's study, the Puerto Asis history is divided in two big stages: before and after oil was discovered around there. The people's thinking is that they have national oil royalties enough to have everything without their participation. However, the oil production is going down and the unemployement is going up.

The methodology that was used can be divided into five stages.

Stage 1. The same as in Alto de los Idolos. The promotor quickly noticed the already explained frame of mind of the population.

Stage 2. The same as in Alto de los Idolos.

Stage 3. The promotor contacted influential local groups and authorities to convince the members of the Municipal Council, elected by popular vote every two years of the importance of the project in order to get their support for the agreement between the National Institute of Health and the Municipality for the construction and financing of the S.S.F. It was decided that the municipality would pay and employ unskilled labourers thus reducing the existing unemployement while the departmental government would contribute a bulldozer for excavation work. Because of the size of the village, a promoter will permanently be living in Puerto Asis throughout the construction period. He organizes the workers paid by the Municipality according to the weekly labour needs, takes care of the materials, and writes monthly reports on the work progress to the Municipality.

Stage 5. Will take place after construction is completed. It will begin with handing over the system to a water supply management board elected by representatives of the community action boards, influential local group and authorities including members of the Municipal council. A promoter will be appointed as a member of the Board.

5.3. PERFORMANCE EVALUATION.

A systematic monitoring programme will be undertaken by the Putumayo Branch of the Rural Basic Sanitation Division and the Putumayo Health Service. The parameters for performance and the samples to be collected will be the same as in Alto de los Idolos project.