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EVALUATION OF THE UTILIZATION OF NEW TECHNOLOGY IN WATER TREATMENT IN LATIN AMERICA

EVALUATION OF THE USE OF NEW WATER TREATMENT TECHNOLOGY IN LATIN AMERICA

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1. BACKGROUND

In spite of the great efforts made in the last two decades, undoubtedly the main environmental problem in Latin America is still water supply, due to its physical and economic magnitude, as well as its direct and indirect influence on health and development. Water treatment is the only way of guaranteeing its effectiveness and for this reason it takes the highest priority.

1.1 Situation of water treatment and supply in Latin America

In accordance with the last Report of the Director of PAHO (1976), 196 million people are covered by water supply services, corresponding to 79% of the urban population (152.7 million) and to 34% of the rural population (43.7 million) (1), and 5,000 million dollars have been invested, during the last two decades, to provide this service.

The variety of socio-economic conditions of the Region and the use of a highly varied range of technical solutions do not make it possible to get a clear global definition or a unique and complete appreciation of the water treatment situation in Latin America and the Caribbean zone. Therefore, only some of the outstanding characteristics of the problem are being listed here:

- The majority of water treatment plants have been the result of existing technical skill. Two factors influence this fact: the importation of technology and the technical and commercial promotion of products and solutions from developed countries; plants are usually constructed and solutions adopted that would be appropriate for countries with a high level of industrial technology; to operate these plants a technology must be used that is not available in most of the countries of the area.

- Local technology, originated and depending on international and technological progress, needs to create a maintenance and operational capacity (personnel, equipment, chemicals), which at the same time depends on the commercial and technical processes of developed countries (2).

- The problem becomes greater when the economic aspect is considered, as the complexity of solutions used, as well as an excess of equipment, rise the cost (approximately one thousand million dollars in the last two decades), which is around 20% of the total drinking water urban investments — more than 10% of rural investments (by elimination of treatment) (2).

- When the water treatment situation for the next five years is analyzed, it is easy to foresee that the mentioned problems will be aggravated because of the almost duplication of the population served, deterioration of the water supply sources as results of higher pollution, shortage of water resources for other uses, increase of equipment and consumption and the occurrence of a growing inflationary process that, together with the previous factors, will cause a great increase in the investments needed for water treatment (twice to three times this decade's investment).

- A more accelerated progress in water treatment technology and a significant decrease of the time span between technological discoveries and their application (2).

1.2 Technological solutions (3)

There are three general types of water treatment plants in Latin America:

a) Conventional - Which use rather conservative process and design criteria (design theories from the beginning of 1960 or before), presenting normal slow and rapid filtration plants.

b) Patented systems - Most technological improvements in the area have been the result of solutions which have been or are in the process of being patented, originating more economical and/or more efficient projects. For this reason most of the larger water treatment plants in Latin America use various processes and solutions of this type.

c) Utilization of new technology - Technological progress in the water treatment field in the last years has been really outstanding and produced substantial modifications in the operation of the treatment processes so as in the utilization of new processes and systems.

From the research studies carried out at CEPIS (3) (4) it is inferred that there are no less than 90 treatment plants in Latin America that have been designed and partially or totally built with the new technological criteria; their capacity ranges from 6 l/s (Guarico, Venezuela) up to 33,000 l/s (Guarau, São Paulo, Brazil.

1.3 CEPIS/PAHO's action (4)

In accordance with the goals established at the Meeting of Health Ministers held in Santiago, Chile, and with PAHO's policy, CEPIS has developed its activities in the following water treatment areas:

- Collection of technical literature.

- Basic and applied research on coagulation agents, hydraulic flocculation, laminar sedimentation, use of new filtrating media, elimination of filters control, simplification of filters washing, use of modular compact plants, use of direct filtration.

- Information.

- Transference and dissemination of knowledge.

- Furtherance of new and adequate technology utilization.

- Technical advisory services.

At this time of rapid technical evolution there is concern not only to satisfy actual needs but also as regards achieving foresight of this problem in the future in view of the growing magnitude of the water supply and water treatment problem and of its influence in health and development.

2. OBJECTIVES (5)(6)

The objectives of the research were:

2.1 General

- Identification of new technological criteria.

- Determination of the technical efficiency of unit processes and of plants designed with new criteria.

- Costs determination.

- Determination of the grade of adaptability of the projects with the existing socio-economic level.

- Complementary - Dissemination of results and further modification of design and operation criteria.

2.2 Specific

To evaluate the hypothesis of programs, techniques, and methods used, determining their original hypothesis, ideal technical conditions and conditions of normal operation, related to their variables (independent, intermediate, and dependent).

3. RESEARCH PROGRAM (5)(6)

The research program contemplated the following:

3.1 Study to determine the new technology in the water treatment field.

3.2 Identification of the plants and projects in Latin America using this new technology.

3.3 Selection of the plants to be evaluated.

3.4 Selection of research methodology:

a) Research extent and parameters to be evaluated.

b) Standards establishment and measuring criteria:

- Type of measurement. Laboratory
  Plant

- Measurement sensitivity.

- Confidence limits.

- Validity and objection criteria.

- Determination of factors: internal and/or external.

- Representation of results to enable analysis.

3.5 Data collection.

3.6 Analysis and comparison of data with those from similar plants, designed with other technological criteria.

3.7 Conclusions.

3.8 Dissemination.

4. EXECUTION OF THE PROGRAM (5)(6)

The research was made according to the program detailed in table 1, identifying the projects listed in table 2, from which the following water treatment plants of the cities listed below were selected:

- Cochabamba (Bolivia), with a 235 l/s capacity.

- Linhares, Espírito Santo (Brazil), with a 60 l/s capacity.

- Prudentópolis, Parana (Brazil), modular project with a 12 l/s capacity.

- Cuenca (Ecuador), with a 860 l/s capacity, and

- El Imperial (Perú), with a 36 l/s capacity.

Contracts were also signed with the respective water treatment supply administrative agencies for the execution of works in the field, carrying out the analysis and technical research listed in table 3 and data and socio-economical indicators given in table 4.

The following research factors must also be mentioned as limiting factors:

- Economical resources constraints.
- Execution time constraints.
- Presentation of good and constant water quality, which limited the investigation to removal of physical (turbidity and color) and bacteriological characteristics.
- As main problem mention must be made of the collaboration of the systems' administrative agencies; this was excellent in two projects, regular in one and frankly unefficient in two, even though they had been donated laboratory equipment and additional salaries for the conduction of these studies.

5. COST AND FINANCING (5)(6)

The cost of this research reached the sum of US$79,884.00, distributed as shown in table 5. This was financed with funds from PAHO, the International Development Research Centre (IDRC) and the University of Oklahoma, the last one under the auspices of the Agency for International Development (AID).

6. RESULTS AND CONCLUSIONS (5)(6)

6.1 Technical - immediate

6.1.1 Than with the use of new technological criteria it is possible to design, build, and operate extraordinarily compact and simple plants, with a very low cost and high technical efficiency, and without mechanized equipment of any kind.

6.1.2 Than the use of new technology partially implies the optimization of processes and use of higher unit loadings, which results in smaller, and therefore cheaper plants.

6.1.3 Than the use of high technology is not in any way contrary to the existing grade of technology in the countries to operate and maintain such treatment plants.

6.1.4 Than the new technological concepts lead to simplification of processes as well as of operation, adequating them for countries of low industrial development.

6.1.5 Than the use of new technological criteria is not limited by the size of the plant, nor by water quality.

6.1.6 Than simplified plants designed with new technological criteria and without mechanized equipment may obtain high efficiency and four of the five plants fulfill the present AWWA water quality standards.

6.1.7 Than the design stage must necessarily include factors of socio-economical development as limiting elements for the selection and use of treatment processes.

6.2 Administrative - immediate

6.2.1 The adoption of solutions based on new technological criteria brings with itself the need for greater specialization of the professional staff.

6.2.2 The use of solutions which are radically different from conventional methods causes a certain restraint on the part of designers and/or management staff, which becomes even more manifest when low costs become evident.

6.2.3 Plants designed with new technological criteria which use higher unit loadings than those used by conventional plants are easier to operate, but they require qualified personnel as any operational error results in evident differences in the effluent water quality.

6.2.4 It must be pointed out that during the evaluation period of the indicated plants no special maintenance nor operational problems were presented due to the type of criteria used in the design.

6.3 Economical - immediate

6.3.1 New projects of rapid filtration plants, solved with the indicated technical criteria, cost around a 40 to 50% of the plants designed with conventional criteria and between a 45 to 60/ of the plants using patent processes.

6.3.2 Plants with direct filtration, within their own limits for use and application, are more economical — 15 to 25% of the plants with rapid filtration.

6.3.3 Referring to costs of unit processes, they are much lower than the conventional ones:

Dosification	10% of dry feeders
Rapid mixing	same
Flocculation	120%
Laminar sedimentation	30-40% of conventional sedimentation
Filtration	40-50% of conventional rapid filters

(Percentages corresponding to mean values).

6.3.4 Comparative studies show that operation and maintenance costs are lower than those of conventional plants with the same capacity, between 10 to 15% (mean values); in some cases savings of more than 40% are obtained, due mainly to the process optimization (especially of dosification, mixing, and flocculation), which causes a decrease of chemical substances.

Furthermore, the lack of mechanical equipment brings as a consequence an easier operation and maintenance at lower cost.

6.4 Present

6.4.1 Massive use of new technology as is the case of the Parana State, Brazil, where SANEPAR carried out a program to build modular plants for 124 cities with a population ranging from 2,000 to 30,000 inhabitants, and the modification of 53 conventional plants to serve cities of 30,000 to more than 1'000,000 inhabitants; in the latter instance it is expected to duplicate the plants' capacity and to finance around 50% of the cost, only with savings achieved by the use of coagulants.

6.4.2 To pull down the existing taboo on the use of new technological criteria which has brought up programs for the evaluation and new design of large treatment plants to a 50% of the cost of conventional solutions, such as those done in La Atarjea, in Lima, Perû; Guadalupe, Tres Ríos, in San Josê, Costa Rica.

6.4.3 The execution of a program to "Establish Evaluation Criteria of Water Treatment Plants" is considered convenient after it has been found out that, fortunately, the more economical alternative (40%) lies in the modification of existing plants — their capacity can be normally duplicated and even trebled.

Table I

CHRONOGRAM OF ACTIVITIES FOR THE EVALUATION OF WATER TREATMENT PLANTS

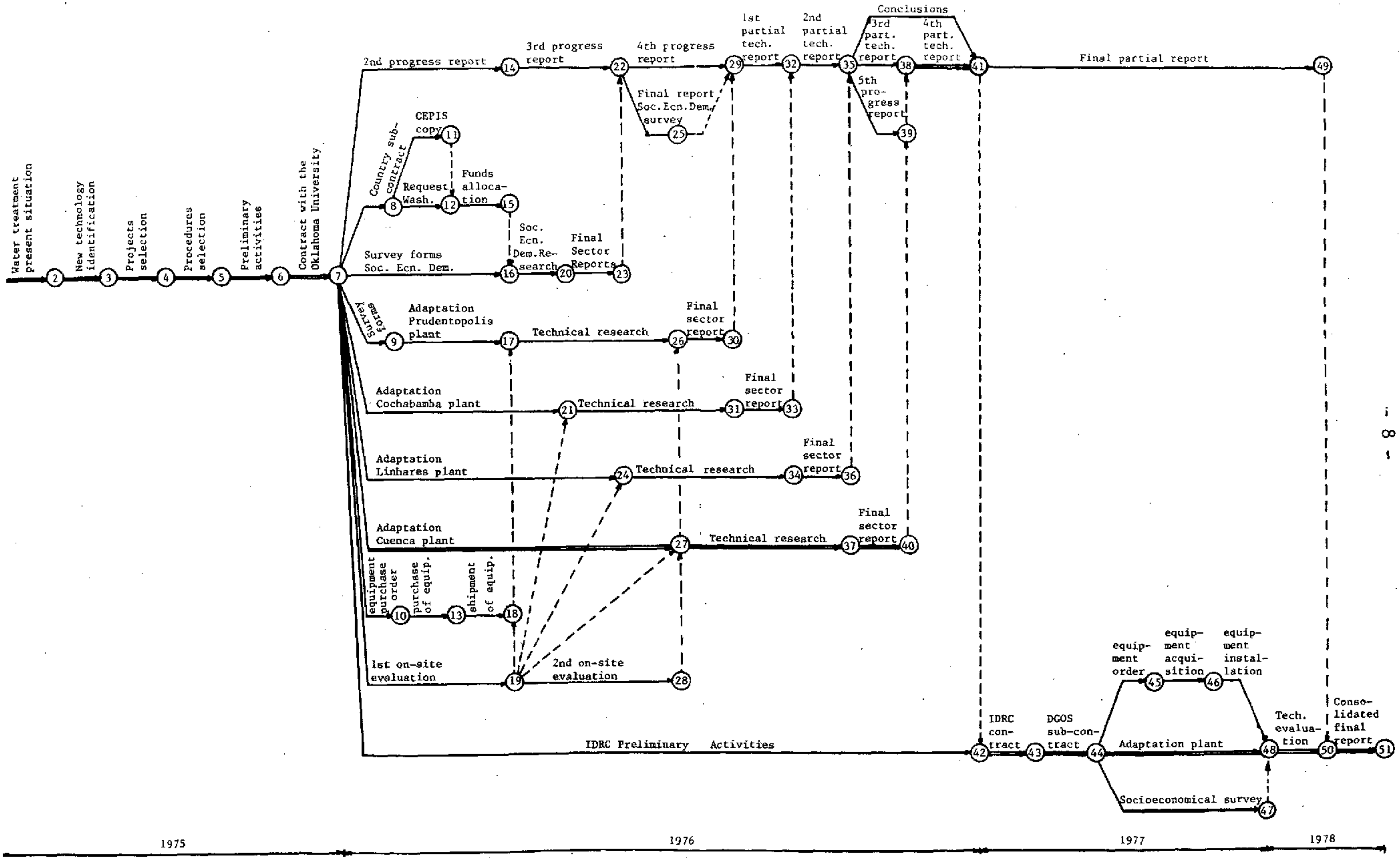

Table 2

PROJECTS WHICH USE NEW TECHNOLOGICAL CRITERIA IN WATER TREATMENT
SURVEY RESULTS - DATA PROVIDED BY COUNTRIES - 1977

Country	City	Population (inhab.)	Flow (l/s)	Project		Floccu - lation		Sedi- menta- tion		Filtration			Progress		
				New	Up-grading	Mechan-ics	Hydrau-lics	Up-flow	Laminar	Slow	Rapid	Direct	Project	Building	Opera-tion
Argentina	21 systems	< 3,000		x						x					x
Bolivia	Cochabamba	100,000	230	x			x		x		x				x
Brasil	Rio de Janeiro	4'000,000	12,000		x				x		x				x
	Barramansa	60,000	180		x				x						x
	Sao Paulo		2,000		x										
			33,000	x							x			x	
	Colatina		30	x								x			
	Linhares		70		x							x			
	Ponta Grossa												x		x
	Camboriu			x											x
	Rio Negro		62	x					x		x				x
	Araucaria		11	x					x		x				x
	Cornelio Procopio		53	x		x			x		x				x
	S. Antonio de Platina		66		x				x		x				x
	Cambara		173		x	x			x		x				x

Cont. Table 2

Country	City	Population (inhab.)	Flow (1/s)	Project: New	Project: Up-grading	Flocculation: Mechanics	Flocculation: Hydraulics	Sedimentation: Up-flow	Sedimentation: Laminar	Filtration: Slow	Filtration: Rapid	Filtration: Direct	Progress: Project	Progress: Building	Progress: Operation
	Ciarnorte		150	x		x			x		x				x
	Guaratuba		33	x								x			x
	Foz do Iguazu		300	x		x			x		x				x
	Rio Grande		8,000	x		x			x		x		x		
	CETESB (Modular Projects)		< 60	x											
	SANEPAR (Modular Projects) 56	< 30,000	11 - 60	x									x	x	
	Bocatu		300	x					x		x				x
	Prudentopolis		11	x			x		x		x				x
Colombia	Cucuta		800		x						x			x	
	Bogota (Tibito)		8,000		x						x			x	
	(El Sapo)		24,000	x								x	x		
	Medellin (Ayura)		2,000		x							x	x		
	(V. Hermosa)		1,600		x						x				x
	Cali (R. Cali)		1,000		x						x				x
	(R. Cauca)		2,500		x						x				x
	(P. Mallarino)		4,000	x							x			x	
	Jumbo		15			x			x		x				x
Cuba	Sta. Clara - Cienfuegos		1,200								x				x
Chile	Santiago (Vizcachas)		9,000						x		x			x	
	(Lo Castillo)		200						x		x				x

Cont. Table 2

Country	City	Population (inhab.)	Flow (l/s)	Project		Flocculation		Sedimentation		Filtration			Progress		
				New	Up-grading	Mechanics	Hydraulics	Up-flow	Laminar	Slow	Rapid	Direct	Project	Building	Operation
	Osorno		568								x				x
	Rancagua		1,340				x		x		x				x
	Valdivia		1,020								x				x
Ecuador	Cuenca	120,000	860	x			x		x		x				x
	Santo Domingo	90,000		x											
	Zaruma	21,000	61	x								x	x		
	Baeza			x						x					x
	San Francisco de B.			x						x					x
	Guayaquil	1'000,000			x				x		x		x		
Mexico	Pachuca		45			x			x		x				x
	Ixtapan de la Sal		60					x			x				x
Paraguay	Asuncion		500	x					x		x				x
Peru	Lima		10,000		x						x				x
	Arequipa		1,600		x						x				x
	Chiclayo				x				x		x				x
	El Imperial		36	x			x		x		x				x
	Barranca		160	x			x		x		x			x	
	DGOS (Modular Projects)		< 60	x		x			x		x				

Cont. Table 2

Country	City	Population (inhab.)	Flow (1/s)	Project		Flocculation		Sedimentation		Filtration			Progress		
				New	Up-grading	Mechanics	Hydraulics	Up-flow	Laminar	Slow	Rapid	Direct	Project	Building	Operation
Rep. Dominicana	Monte Cristy		100	x			x		x		x				x
	Higey		185	x			x		x		x				x
	S. Fco. de Mag		500	x			x		x		x				x
	La Romana		500	x			x	x			x				x
	Hato Mayor		100	x			x	x			x				x
	Bonao		260	x			x	x			x				x
	Maimon		80	x			x	x			x				x
	Navarrete		80	x			x	x			x				x
	Monte Plata		80	x			x	x			x				x
	Sabana de la Mar		85	x			x	x			x				x
	Sanchez		120	x			x	x			x				x
Surinam	Kwatta Leidingen	25,000	67					x			x				x
	Wonoredjo	5,000	10								x				x
Venezuela	15 plants		25 - 300	x								x			x
	Caracas (La Mariposa)		1,680						x		x				x
	Guarico		6						x						x
Plants total	to April 1978: 163														

Table 3

DETAILS OF RESEARCH STUDIES

Project No.	Name	Responsible agency	RESEARCH STUDIES: Normal operations (hourly data required) — General	Raw water	Chemical dosage	Settled water	Filtered water	Special tests
1	Water Treatment Plant Cochabamba, Bolivia	SEMAPA	Date Hour Flow	Turbidity Color pH Alkalinity	Alum Lime Chlorine	Overflow rate Turbidity Color pH Alkalinity Residual alum	Turbidity Color Residual alum Filtration rate Water level Loss of head Length of filter run Backwashing time	Adaptation of the plant Determination of optimum coagulation conditions (laboratory) Tracer tests in rapid mixing, flocculation and settling units Parameters influencing settling units Parameters influencing filtration processes
2	Water Treatment Plant Linhares, Brazil	FSESP	Date Hour Flow	Turbidity Color pH Alkalinity	Alum Lime Chlorine	———	Turbidity Color Residual alum Filtration rate Water level Loss of head Length of filter run Backwashing time	Determination of optimum coagulant dosage (laboratory) Filtration and filter washing characteristics
3	Water Treatment Plant Prudentopolis, Brazil	SANEPAR	Date Hour Flow	Turbidity Color pH Alkalinity	Alum Lime Chlorine	Overflow rate Turbidity Color pH Alkalinity Residual alum	Turbidity Color Residual alum Filtration rate Water level Loss of head Length of filter run Backwashing time	Operator training Determination of optimum coagulation conditions (laboratory) Tracer tests in flocculation and sedimentation units Parameters influencing sedimentation Filtration and backwashing characteristics
4	Water Treatment Plant Cuenca, Ecuador	ETAPA	Date Hour Flow	Turbidity Color pH Alkalinity	Alum Lime Chlorine	Overflow rate Turbidity Color pH Alkalinity Residual alum	Turbidity Color Residual alum Filtration rate Water level Loss of head Length of filter run Backwashing time	Adaptation of the plant Determination of optimum coagulation conditions (laboratory) Tracer tests in settling units Parameters influencing sedimentation Comparative study of settler efficiency Comparative study of constant-rate and declining rate filters
1	Water Treatment Plant **El Imperial, Perú**	**DGOS**	Date Hour Flow	Turbidity Color pH Alkalinity	Alum Lime Chlorine	Overflow rate Turbidity Color pH Alkalinity Residual alum	Turbidity Color Residual alum Filtration rate Water level Loss of head Length of filter run Backwashing time	Adaptation of the plant Determination of optimum coagulation conditions (laboratory) Tracer tests in rapid mixing, flocculation and settling units Parameters influencing settling units Parameters influencing filtration processes

Table 4

PARAMETERS WHICH PERMIT DETERMINATION OF TECHNICAL-SOCIAL LEVEL FOR COMMUNITIES IN DEVELOPING COUNTRIES

Number	Technical-social factors	Probable selections	Weight factor
1	Education level	1	0
		2	5
		3	10
		4	15
2	Distribution of labor force	1	0
		2	5
		3	10
		4	15
3	Characteristics of incomes	1	0
		2	4
		3	8
		4	12
		5	15
4	% of foreign workers	1	4
		2	3
		3	2
		4	1
		5	0
5	School attendance	1	0
		2	5
6	Higher educational level	0	0
		1-6	2
		7-10	4
		11-12	7
		12+	10
7	Distance to nearest school	1	3
		2	2
		3	1
		4	0
8	Availability of technical training and vocational programs	1	5
		2	0
9	Compulsory primary education	1	10
		2	0
10	Availability of in-service training programs	1	5
		2	0
11	Universities availability	1	10
		2	0

Cont. Table 4

Number	Technical-social factors	Probable selections	Weight factor
12	Specialty of chemistry at university level	1	3
		2	0
14	% of unemployment	1	0
		2	5
15	Availability of extension services	1	3
		2	0
16	Availability of university students	1	0
		2	3
17	Level of available technology	1	0
		2	5
		3	10
		4	15
18	Government as user of unskilled labor force	1	0
		2	5
19	Availability of public positions	1	5
		2	0

Technical-social level	Scoring
1 - Basic	1 - 23
2 - Medium	24 - 51
3 - Relatively advanced	52 - 93
4 - Advanced	94 -133

Cont. Table 4

LOCAL RESOURCES
DATA TO BE INVESTIGATED

1. LOCAL RESOURCES

1.1 <u>Equipment</u>

Water meters
Welding equipment
Acetylene equipment
Register fittings
Laboratory equipment
Portable electric units
Motors
Water pumps

1.2 <u>Processed materials</u>

Pipes: clay, cement, plastic, asbestos-cement, copper, cast, iron
Fittings: elbows, etc.
Paints
Valves
Tanks
Vacuum breakers
Heat exchangers

1.3 <u>Normal materials</u>

Sand
Gravel
Water
Gasoline

1.4 <u>Chemicals</u>

Alum sulphate
Ferric chlorine
Activated carbon
Soda ash
Chlorine
Ozone
Laboratory chemicals

1.5 <u>Water resource</u>

Surface - river or current
Lake or reservoir
Underground
Sea water

Cont.

2. DEMOGRAPHIC DATA

2.1 Present population

2.2 Growing rates

3. RAW WATER QUALITY

3.1 Bacteriological quality

3.2 Physical quality

3.3 Chemical quality

Category	Availavility of resource
1	Operational equipment
2	Processed materials
3	Basic materials
4	Chemicals
5	Availability of under-ground waters

Table 5

COST AND FINANCING

Institution		Equipment and Laboratories 0	Installation and Operation 1	Technical Personnel 2	Publications and Reports 3	Administration and others 4	Cost US$ Total 5	Cost US$ %
CEPIS/PAHO		3,000	-	28,600	2,300	7,824	41,724	52.23
University of Oklahoma		7,000	10,000	5,000	2,000	1,000	25,000	31.30
International Development Research Centre		10,278	2,882	-	-	-	13,160	16.47
Cost	Total	20,278	12,882	33,600	4,300	8,824	79,884	100
	%	25.38	16.13	42.60	5.38	11.05	100	