Technical Documents Series 5

FINAL REPORT

INTERLABORATORY QUALITY CONTROL STUDY - MINERAL/PHYSICAL PARAMETERS

PRELAB

PAN AMERICAN CENTER FOR SANITARY
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Within CEPIS staff, Dr. Cliff J. Kirchmer acted as project coordinator and was in charge of preparing this report. Eng. Ricardo Haddad collaborated in the editorial revision and translation into Spanish and Mr. Hernán Vega carried out the statistical calculations.

PARTICIPATING LABORATORIES

Fifty-nine laboratories in twenty-two countries took part in study #1, Mineral/Physical Analyses. The participating laboratories were:

ARGENTINA

Departamento de Laboratorios
Dirección de Obras Sanitarias
de la Provincia de
Buenos Aires

Departamento de Laboratorios
Empresa Obras Sanitarias de la
Nación
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Dirección de Saneamiento Ambiental
Córdoba

Dirección de Saneamiento - Aguas
San Salvador de Jujuy

Laboratorio de Hidrología
Dirección de Bromatología
Entre Ríos

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de Saneamiento (Hidrológico)
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Laboratorio de Saneamiento Ambiental
Departamento de Saneamiento Ambiental
Secretaría de Salud Pública
Tucumán

Laboratorio de Saneamiento
Area Saneamiento
Secretaría de Estado de Salud Pública
Buenos Aires

Sección Aguas
Departamento de Ciencias Biológicas
de la Facultad de Bioquímica
Universidad Nacional del Litoral
Santa Fe

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Medical Department
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Companhia de Tecnología de
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São Paulo

Companhia Riograndense de Saneamento (CORSAN)
Porto Alegre, Rio Grande do Sul

Laboratório de Análises D'Águas da Cia. Águas e Esgotos do Maranhão (CAEMA)
Sao Luis, Maranhão

Laboratório Central de Contrôle (EMBASA)
Salvador, Bahía

Fundaçao Estadual de Engenharia do Meio Ambiente (FEEMA)
Rio de Janeiro

Laboratório Central
Companhia de Água e Esgotos da Paraíba (CAGEPA)
João Pessoa, Paraíba

Instituto de Tecnología e Pesquisas de Sergipe (ITPS)
Sergipe

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Laboratorio de Química y Microbiología de Aguas
Sección Ingeniería Sanitaria
Universidad de Chile
Santiago

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Dirección de Obras Sanitarias
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Bogotá

Instituto Nacional de Fomento Municipal
Laboratorio de Aguas del INSFOPAL
Bogotá

Laboratorio de Aguas-Suelos
Corporación Autónoma Regional del Valle del Cauca (CVC)
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Santiago de Cuba, Oriente

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Laboratorio de Aguas de la Empresa Municipal de Agua Potable
Planta "El Placer"
Quito

Laboratorio Químico "La Toma"
Empresa Municipal de Agua Potable
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Laboratoire d'Eau Potable
Services Hydrauliques
Port-au-Prince

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Laboratorio de Análisis de Agua
Servicio Autónomo Nacional de Acueductos y Alcantarillado
Tegucigalpa

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National Water Authority
Montego Bay

Chemical and Bacteriological Laboratory
The Water Commission
Kingston

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Centro de Investigación y
Entrenamiento para el Control
de la Calidad del Agua (CIECCA-SRH)
México

Departamento de Investigación y
Laboratorio de la Dirección
General de Agua Potable y
Alcantarillado
México

Laboratorio Central
Dirección General de Operación de
Sistemas de Agua Potable y
Alcantarillado
México

Laboratorio de Agua Potable
Dirección General de Aguas y
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Facultad de Ingeniería
Universidad Central de Venezuela
Caracas

Laboratorio de Aguas
Instituto Nacional de Obras
Sanitarias
Caracas

Laboratorio de Química Sanitaria
Departamento de Ingeniería
Sanitaria
Facultad de Ingeniería
Universidad Central de Venezuela
Caracas

SUMMARY

This report presents the results of a interlaboratory quality control study on basic mineral and physical parameters undertaken by the Pan American Center for Sanitary Engineering and Environmental Sciences (CEPIS). Fifty-nine water analysis laboratories in twenty-two Latin American and Caribbean countries participated in the study.

Synthetic water samples were prepared at two levels of concentration (high and low) for pH, total alkalinity, electrical conductivity, total dissolved solids, total hardness, calcium, magnesium, sodium, potassium, chloride, fluoride, and sulfate.

The results were evaluated both qualitatively and quantitatively using statistical analysis. A summary of selected statistical parameters indicating precision and accuracy of the results is given in the following table.

STATISTICAL SUMMARY
Mineral (and Physical) Parameters

Parameter	True value	Number of laboratories analyzing parameter	No. of outliers	Mean of all values	Mean of values remaining after rejection of outliers	Precision as relative standard deviation (coefficient of variation)	Accuracy as % relative error
pH	7.7 units	59	1	7.15	7.18	6.63 %	- 6.70 %
	8.6 units	59	2	7.71	7.82	5.51 %	- 9.11 %
Electrical conductivity, 25°	157.0 µmhos/cm	40	2	169.78	157.92	10.34 %	+ 0.59 %
	603.0 µmhos/cm	40	4	589.75	589.53	9.34 %	- 2.23 %
Total dissolved solids, 180°	71.7 mg/l	54	3	116.35	118.25	25.93 %	+64.93 %
	318.3 mg/l	54	1	365.23	378.2	13.12 %	+18.82 %
Total hardness	48.6 mg/l as $CaCO_3$	58	2	57.31	51.82	9.20 %	+ 6.63 %
	170.2 mg/l as $CaCO_3$	58	2	182.55	176.59	5.07 %	+ 3.75 %
Calcium	14.5 mg/l	55	3	17.21	15.31	11.53 %	+ 5.60 %
	44.5 mg/l	55	3	53.23	46.09	11.81 %	+ 3.56 %
Magnesium	3.0 mg/l	53	3	8.99	3.35	41.80 %	+11.58 %
	14.4 mg/l	53	3	19.35	14.92	19.61 %	+ 3.62 %
Sodium	5.0 mg/l	32	2	7.03	5.75	34.34 %	+14.9 %
	39.7 mg/l	32	2	40.76	40.43	19.09 %	+ 1.84 %
Potassium	2.7 mg/l	29	2	2.72	2.85	14.08 %	+ 5.47 %
	8.4 mg/l	29	1	8.95	8.70	16.81 %	+ 3.58 %
Total alkalinity	10.4 mg/l as $CaCO_3$	58	3	13.83	12.91	23.15 %	+24.09 %
	35.7 mg/l as $CaCO_3$	58	4	39.71	37.91	9.11 %	+ 6.18 %
Chloride	28.1 mg/l	59	4	30.15	29.98	17.59 %	+ 6.68 %
	86.4 mg/l	59	3	86.65	87.18	13.09 %	+ 0.91 %
Fluoride	0.2 mg/l	43	3	0.26	0.22	38.76 %	+10.38 %
	1.1 mg/l	43	2	1.20	1.18	16.04 %	+ 7.43 %
Sulfate	12.0 mg/l	57	0	10.86	10.86	38.61 %	- 9.47 %
	102.4 mg/l	57	2	92.41	92.28	20.89 %	- 9.89 %

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INTRODUCTION

The study presented in this report was carried out by CEPIS as a part of the Regional Program for Analytical Quality Control in Water and Wastewater Laboratories (PRELAB). When the study was initiated there were seventy-three (73) laboratories in twenty-five (25) countries enrolled in PRELAB.

The principal objectives of this program are:

1. To promote the use of standard methods of sampling and analysis.
2. To incorporate analytical quality control procedures into all routine laboratory practices.
3. To provide information and guidance to laboratory personnel on the use and calibration of the most frequently used instruments for water and wastewater analyses.
4. To evaluate the chemical and microbiological analytical capability of the participating laboratories.
5. To establish the interchange of information and experience between laboratories.

Analytical quality control is usually characterized as being either internal or external. Internal quality control refers to procedures applied within each laboratory to ensure the precision and accuracy of results. External quality control refers to the shipment of samples from a central laboratory for the purpose of providing an external check on analytical results.

The present study falls under the category of external quality control. External quality control is intended to supplement, but not replace, internal laboratory control. Indeed, external quality control can be considered as a check on whether the laboratory being tested has an acceptable internal quality control program.

The study was undertaken principally for the purpose of providing laboratories of PRELAB with information useful for evaluating their performance. An additional reason for the study was to determine the overall performance level of laboratories in Latin America and the Caribbean. We believe this report should prove useful in identifying problems and needs, as well as provide a baseline for evaluating the future progress of laboratories.

DESCRIPTION OF THE STUDY

Seventy-three sets of samples were shipped from EPA to the countries on 22 November 1976. The samples were sent to the PAHO Country Offices for subsequent distribution to the national laboratories.

Some samples were lost in the mail, and therefore in several countries it was necessary to send a second shipment of samples. Of the seventy-three samples mailed out, fifty-nine results were received in CEPIS. The majority of the samples were analyzed and reported to CEPIS during the first semester of 1977.

Statistical analyses of the data were performed using procedures developed previously by the EPA. Statistics were calculated with the aid of a computer program developed in CEPIS for use with the WANG System 2200 microcomputer.

The mineral samples were prepared as concentrates in the EPA laboratory by dissolving known amounts of analytical reagent grade chemicals in distilled water for exact and preplanned concentrations. Each sample was analyzed repeatedly over a period of months to assure stability.

The prepared concentrates were supplied to each laboratory for analysis at two levels of concentration. Each sample was made immediately prior to analysis from concentrates obtained in separate ampules to prevent precipitation of any element. The following analyses were indicated for each sample: pH, total alkalinity, specific conductance, total dissolved solids, total hardness, calcium, magnesium, sodium, potassium, chloride, fluoride, and sulfate.

GLOSSARY OF STATISTICAL TERMS

The statistical measurements used in this report are defined as follows:

Accuracy as % relative error. The signed difference between mean value and the true value, expressed as a percent of the true value.

$$RE = \frac{\bar{x} - x_{true}}{x_{true}} \times 100$$

Confidence limit (95%). The range of values about the sample mean which will include the true mean 95% of the time.

$$C.L. = \bar{x} \pm t_{0.05}\, s/\sqrt{n}$$

where:

t = value from t table with n-1 degrees of freedom
s = standard deviation
n = number of samples

Mean ($\bar{x}$). The arithmetic mean of reported values. The average.

Median. Middle value of all data ranked in ascending order. If there are two middle values, the mean of these values.

Range. The difference between lowest and highest reported values.

Relative standard deviation (coefficient of variation). The ratio of the standard deviation, s, of a set of numbers to their mean, $\bar{x}$, expressed as percent. It is an attempt to relate the deviation (precision) of a set of data to the size of n so that the deviations for differing levels of a parameter can be compared fairly.

$$R.D. = 100\,\frac{s}{\bar{x}}$$

Skewness (k). A pure number, positive or negative, which indicates the lack of symmetry in a distribution. For example, k is positive if the distribution tails to the right and negative if the distribution tails to the left.

Standard deviation (σ), (s). It is the most widely used measure of dispersion of a set of data, and is equal to the square root of the variance. The standard deviation, σ, is the measure of the deviation of the universe. However, in most experimental work with limited

sampling, and in this study, only an estimated standard deviation, s, is measureable. With a normal distribution, the interval $\bar{x} \pm s$ will contain 68% of the observed values.

$$s = \sqrt{\frac{\Sigma x_i^2 - \frac{(\Sigma x_i)^2}{n}}{n - 1}}$$

True value. Those amounts actually added in sample preparation. These are not based on analyses, the latter being used only for verification. True values indicated in the report were provided by the U.S. Environmental Protection Agency (EPA).

TREATMENT OF DATA

Rejection of outliers

Before calculating the statistics for the results obtained by the laboratories, it was necessary to eliminate those extreme values probably caused by gross systematic error. These extreme values were eliminated in two stages. First of all, values more than four standard deviations from the mean were rejected. These values are indicated as R1 on the computer printouts. The two-tail t-Test was then applied to all remaining values at a 99% probability level, that is, with 99% assurance that the additional data points rejected were false and should have been rejected. These values are indicated as R2 in the computer printouts. Statistical calculations are based on values remaining after rejection of outliers. The only exception to this last statement is that of the "mean of all values" (including outliers) which are given in the fifth column of the summary table.

In general, poorer precision (i.e. greater spreading of data around the true value) results in the rejection of fewer outliers. This is because a precision term serves as the denominator in the t-Test and as the precision decreases (i.e. number value increases) the calculated t value grows smaller and there are fewer extreme values rejected as outliers. On the other hand, with better precision and accuracy, the t-Test is more powerful and more outliers are rejected. However, those data rejected in either case are true outliers and procedures should be carefully reviewed for the causes of inaccuracy.

Nature of errors

The following presents a brief description of the nature of errors in physical and chemical analyses in order to facilitate a better understanding of the results and discussion presented in this report.

The error, E, of an analytical result, R, is defined as:

$$E = R - \tau$$

where τ is the true value.

Errors can be classified as random or systematic, and their natures are illustrated in figure 1, where the analyst's attempt to measure the true value is compared to a marksman's attempt to hit the center of a target.

Repeated analysis of different portions of the same sample do not give identical results. The scatter of the measured values is attributed to random errors, so named because the sign and magnitude of the error of any particular result vary at random, and cannot be predicted exactly. Examples of such error are variations in the volumes of reagents added to samples,

inadvertent contamination of sample or glassware, variations in times allowed for chemical reactions, and fluctuations in instrument response.

Systematic errors are indicated by a tendency for results to be greater or smaller than the true value. The presence of this type of error is indicated when the mean of a large number of analyses of the same sample differs from the true value. The term bias is used synonymously with systematic error.

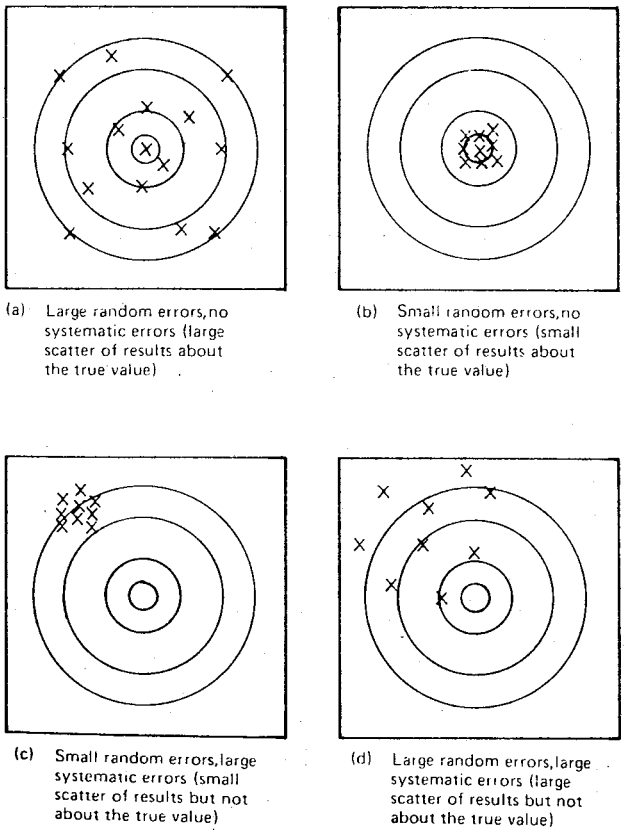
A principal source of bias is often to be found in the method or procedure used in the analysis. There is probably no analytical method that is completely free of bias, and methods are normally chosen which give negligible bias. Unfortunately, such methods do not presently exist for certain determinants. Also, some samples contain interferences which can result in method bias.

Another possible source of bias are the instruments used in measurement. An example would be the use of a spectrophotometer with improper wavelength markings.

Finally, even though using reliable methods and instruments, the analyst himself may introduce bias by not properly following the analytical procedure or by incorrectly calibrating the instruments. Error may also be introduced by the analyst in calculating results from the raw data.

Systematic errors may be either additive or proportional. An additive systematic error is one which has a constant value regardless of the amount of analytically sought constituent present in the sample. A proportional systematic error changes value according to the amount of analytically sought constituent in the sample. As a result of the presence of additive systematic error in many measurements, it is common for the percent relative error to be greater for lower concentrations of sample.

A distinction should be made between errors in analytical results from a single laboratory, and in average results calculated from the results of all laboratories. If an individual result differs from the true value, the difference may be due to random and/or systematic error. When the average result from a large number of laboratories differs from the true value, the difference can generally be attributed to systematic error, random error components having been cancelled out. In some cases, the bias can be traced to the use of inherently inaccurate methods by the reporting laboratories.



(a) Large random errors, no systematic errors (large scatter of results about the true value)

(b) Small random errors, no systematic errors (small scatter of results about the true value)

(c) Small random errors, large systematic errors (small scatter of results but not about the true value)

(d) Large random errors, large systematic errors (large scatter of results but not about the true value)

Figure 1

RANDOM AND SYSTEMATIC ERRORS

DISCUSSION AND CONCLUSIONS

General

While it was not the purpose of this study to evaluate the methods used for analysis, laboratories were requested to specify the methods and analytical reference manuals employed for each determination. While response to this request was not complete, some conclusions were reached. First of all, the manual "Standard Methods for the Examination of Water and Wastewater" was the most frequently mentioned reference. However, only five laboratories reporting using the latest edition (14th edition, 1975). Twenty laboratories indicated the 13th edition (1971) as the principal reference, which made it the most frequently mentioned. Next most frequently reported was the 11th edition (1961), with nine laboratories so indicating, probably due to the fact that there is a Spanish edition. Six laboratories reported using the 12th edition (1965) and one laboratory reported using the 10th edition (1955).

While for many of the basic parameters included in this study methods have remained essentially the same in the different editions of Standard Methods, performance may have been improved for some determinations if the laboratory had used recent Standard Methods. For general improvement of laboratory performance, attention should be given in the Region to providing easier access to recent editions of methods manuals. These manuals should preferably be published in the native language of the countries, and in particular, Spanish and Portuguese methods manuals are lacking.

For some determinations only one method was possible due to the nature of the determination (i.e. conductivity). However, for others, several alternative methods were possible (i.e. fluoride). Specific comments on reported methods are included separately under the discussion for each determination.

The following table relates the number of laboratories to the number of parameters determined.

No. of parameters	No. of laboratories
12	21
11	9
10	10
9	8
8	6
7	1
5	4
TOTAL	59

It can be seen that less than half of the laboratories were able to analyze for all of the parameters included in this study.

Examined from the point of view of individual parameters, it can be seen that some parameters were determined in all or nearly all of the laboratories, while others were analyzed by a significantly fewer number of laboratories. For example, all laboratories reported having analyzed for pH, while only 29 laboratories reported results for potassium.

A major reason for the failure of some laboratories to analyze certain parameters would appear to be a lack of required instrumentation. For example, the laboratories failing to report results for potassium and sodium almost surely did not have access to the needed atomic emission or atomic absorption spectrophotometer. In the case of conductivity measurements, the 19 laboratories not reporting results probably did not have a conductivity meter needed for the determination. It can be concluded, therefore, that at least some laboratories in the Region are limited in their performance by a lack of analytical instrumentation.

On the other hand, the reduced number of laboratories reporting results for fluoride analyses cannot be attributed solely to a lack of instrumentation, since there is a non-instrumental, visual method of performing the analysis. However, the other commonly used analytical methods do depend on instrumentation (i.e. the specific ion electrode method and the SPADNS spectrophotometric method) and it must be concluded that the availability of these instruments together with needed chemicals would have improved the overall participation of the laboratories in the study.

For other parameters included in the study, the participation of laboratories is in general quite good, and the few laboratories not reporting values have done so for reasons particular to their situation and thus no general conclusions seem applicable.

An important source of error in some laboratories could be the analytical balance. Weighing is included in virtually all analytical procedures, either directly (as in the total dissolved solids determination) or indirectly (as in the preparation of standard solutions). While the following discussion does not make continual reference to the analytical balance as a source of error, it should be realized that an accurately calibrated balance is a basic requirement for good analytical performance.

pH

Nearly all laboratories reported using a potentiometric method based on measurement with a pH meter. However, two laboratories reported using a colorimetric method, indicating that they did not have a functioning pH meter available.

The pH tests in this study presented reasonably good precision, but very poor accuracy. True values of pH for the samples were determined by means of repeated measurements under controlled conditions in the EPA laboratory

in Cincinnati, Ohio. In comparison with these true values, the reported values in this study showed a very definite negative bias; that is, the results reported by participating laboratories were in nearly every case less than the true value. This is surprising, since it is generally assumed that pH measurements can be made with high accuracy. Indeed, the results of a previous study by the EPA in the United States indicated that the pH test by meter had the best accuracy (and precision) of all the mineral/physical parameters measured. (1)

It is not clear why there was such a high negative bias in the present study. Special instructions were given for measuring pH and it is possible that some laboratories did not follow them strictly. Also, it is known that accurate readings are obtained slowly in poorly buffered samples, and particularly when changing from buffered to unbuffered samples after standardization. Weakly buffered samples should be stirred during measurements. Poor quality distilled water may also have contributed to the low results.

Defective electrodes can also contribute to errors in measurement. Most are aware of the need to care for the glass membrane electrode, but the reference electrode should also be properly maintained. For the reference electrode, it is particularly important that the liquid junction be properly maintained to provide a flow of potassium chloride.

Electrical conductivity

Due to the definition of electrical conductivity, there was only one possible method for its determination. However, commercial instruments vary considerably in quality and sensitivity of measurement, and their accuracy is highly dependent on careful calibration.

The electrical conductivity test gave the most accurate results (as measured by percent relative error) of all the determinants included in the study. Precision, as measured by relative standard deviation, was less satisfactory, exceeding the values reported in Standard Methods. (2) The following table compares the precision and accuracy of the results obtained in the present study (underlined) with those reported in Standard Methods.

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(1) FWPCA Method Study 1, Mineral and Physical Analyses, Federal Water Pollution Control Administration, Division of Water Quality Research. Analytical Quality Control Laboratory, Cincinnati, Ohio 45202. June 1969.

(2) Standard Methods for the Examination of Water and Wastewater, 14th edition, 1975. APHA-AWWA-WPCF, p. 75.

Conductivity µmhos/cm	No. of results	Rel. standard deviation, %	Relative error, %
147.0	117	8.6	9.4
157.0	38	10.34	+ 0.59
228.0	120	8.4	3.0
303.0	120	7.8	1.9
603.0	36	9.34	- 2.23

The principal source of error in conductivity measurements is the instrument itself. The electrodes should be maintained in good condition, and proper calibration procedures should correct for any variations in the cell constant.

Total dissolved solids

The form sent to the laboratories specified that the samples should be dried at 180°C, and this was the procedure followed in most cases. However, four laboratories reported using a lower temperature of 103-105°C, and one laboratory indicated having estimated total dissolved solids from conductivity measurements. In general, samples containing inorganic salts, such as those analyzed in this study, should be dried at 180°C. Only samples with high organic content should be dried at a lower temperature to avoid loss of volatiles.

The gravimetric determination of dissolved solids showed poor precision and positive bias for both samples. As is usually the case, relative standard deviation and relative error were greater for the sample with lower concentration of solids. Of the 54 laboratories reporting, three results were rejected at the lower concentration in the test for outliers while, due to the large spread of values, only one value was rejected at the higher concentration.

It is well known that mechanically occluded water and water of crystallization are difficult to remove completely when drying solids. To remove the maximum possible amount of water, samples should be dried to constant weight. This is usually interpreted to mean that not more than a 0.5 mg weight change occurs between two successive series of operations consisting of heating, cooling in a desiccator, and weighing.

The Pan American Center for Sanitary Engineering and Environmental Sciences is a regional technical center of the Pan American Health Organization (PAHO/WHO) located in Lima, Peru. CEPIS was established in 1968 to provide technical and scientific assistance for the American Region, to serve as a regional information and reference center, to collaborate with the countries in training activities, and to promote research applied to environmental problems.

CEPIS carries out its program in close collaboration with the Division of Environmental Health of PAHO and staff consultants include experts in air pollution, industrial hygiene, water quality and water resources development, potable water treatment, wastewater treatment, water chemistry and laboratories, systems analysis and computer sciences, technical and scientific information and solid waste management.

This series of Technical Documents was initiated in 1975 in order to intensify the dissemination of information and to contribute to the development of environmental technology compatible with the situation and resources of the Latin American and Caribbean countries. Through the distribution of documents providing details of scientific and technical advances, the Center hopes to support the solution of environmental problems in the Region. These publications are intended for use by the technical and scientific community, including professionals and technicians in government agencies of environmental protection and public health, university professors and students, and other specialists working to improve the environment.

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No. 2 *Polímeros naturales y su aplicación como ayudantes de floculación. 1975. 32 pp.*

No. 3 *Guía para la evaluación de laboratorios bacteriológicos de análisis de aguas. Revised edition. 1978. 62 pp.*

No. 4 *Guide for the evaluation of water laboratories - physical and chemical analyses. 1979. 90 pp.*

No. 4 *Guía para la evaluación de laboratorios de aguas - análisis físicos y químicos. 1979. 95 pp.*

No. 5 *FINAL REPORT - Interlaboratory quality control study - Mineral/physical parameters - PRELAB*

No. 5 *INFORME FINAL - Estudio de control de calidad entre laboratorios - Parámetros mineral/físicos - PRELAB*

Total hardness

The only method reported by the laboratories for determination of hardness was the complexometric EDTA titration method. However, some variations in the method, such as the use of different end-point indicator dyes, were also indicated.

Fifty-eight laboratories reported results for this analysis, with only two results being rejected at each level of concentration. Precision and accuracy can be considered acceptable, although better results should be attainable due to the simplicity and inherent accuracy of the method. The following compares results obtained for this study (underlined) with those reported in Standard Methods:

Total hardness	No. of results	Rel. standard deviation	Percent rel. error
48.6	56	9.20	+ 6.63
170.2	56	5.07	+ 3.75
610	56	2.9	0.8

Calcium

Most laboratories indicated having used the EDTA titration method for determination of calcium. However, three laboratories reported having used the atomic absorption spectrophotometric method, one laboratory the flame (emission) photometric method, one laboratory the permanganate titrimetric method, and two laboratories reported having determined calcium by unspecified gravimetric procedures. In addition, two laboratories reported having calculated the results for calcium, but did not indicate the basis for the calculations.

Fifty-five of the fifty-nine participating laboratories reported results for analysis of calcium. Of these, three results were rejected as outliers at each level of concentration.

Statistical analyses of remaining results indicated acceptable values for precision and accuracy. However, as in the case of measurement of hardness, due to the inherent simplicity and accuracy of the method, increased accuracy and precision should be possible.

The following table compares results obtained in this study (underlined) with those given in Standard Methods for a previous study:

Calcium mg/l	No. of laboratories	Rel. standard deviation, %	Relative error, %
14.5	52	11.53	+ 5.60
44.5	52	11.81	+ 3.56
108	44	9.2	1.9

Individual laboratories can improve performance by taking more care in preparing and standardizing the EDTA titrant, and reducing human errors in measurement.

Magnesium

Most laboratories did not determine magnesium directly, but rather calculated its value as the difference between the analytical results for total hardness and calcium determinations. However, five laboratories reported having determined magnesium directly by the gravimetric method, four laboratories used the atomic absorption spectrophotometric method, and six laboratories indicated having used an EDTA titration procedure.

Since most laboratories did not determine magnesium directly, the precision and accuracy of the results are limited by the precision and accuracy of the total hardness and calcium measurements.

Precision and accuracy for the lower level sample was unsatisfactory, and can be understood by realizing that the values were calculated as the difference between the higher values for total hardness and calcium.

For the higher concentration level, while precision was poor, accuracy as measured by relative error was quite good. This is probably due to a compensatory effect of differences between results cancelling out errors as well as summing them. A comparison of results in this study (underlined) with results given in Standard Methods for direct analysis by atomic absorption and gravimetry, is indicated in the following table:

Magnesium mg/l	No. of laboratories	Rel. standard deviation, %	Relative error, %
0.200 (AA)	-	10.5	6.3
3.0	50	41.80	+ 11.58
14.4	50	19.61	+ 3.62
82 (Grav.)	8	6.3	4.9

These results indicate that improved precision and accuracy could be obtained if more laboratories would measure magnesium directly. Atomic absorption is the preferred method for direct measurement, since the gravimetric method is quite tedious and requires that the permanganate method be used for calcium in order to remove calcium prior to the magnesium determination.

Sodium

The majority of the laboratories reported having used the flame (emission) photometric method for determination of sodium. Five laboratories employed the atomic absorption spectrophotometric method, one laboratory used a specific ion electrode, and one laboratory reported having calculated the sodium concentration on the basis of an anion-cation balance.

Only 32 of the 59 participating laboratories reported having performed this analysis, undoubtedly indicating that many laboratories lack the required flame photometer or atomic absorption spectrophotometer. Two results were rejected as outliers at both the high and low levels of concentration.

Precision, as measured by relative standard deviation, was lower than might be expected (34.34% and 19.09% respectively for low and high concentrations). There was a considerable difference in accuracy for the two levels of concentration. While accuracy as percent relative error for the lower concentration was a relatively high + 14.9%, results for the higher concentration gave a very satisfactory + 1.84%.

A comparison of results in this study (underlined) with that reported by Standard Methods is given in the following table:

Sodium mg/l	No. of results	Rel. standard deviation, %	Relative error, %
5.0	30	34.34	+ 14.9
19.9	35	17.3	4.0
39.7	30	19.09	+ 1.84

Possible sources of error in this measurement include errors in the preparation of calibration standards and errors related to the instrument used.

Potassium

As for sodium, most laboratories reported using the flame (emission) photometric method for the analysis of potassium. Five laboratories reported using the atomic absorption spectrophotometric method.

Only 29 of the 59 participating laboratories reported results for this parameter and, as in the case for sodium, the limited response was probably due to a lack of proper instrumentation in the other laboratories. Two outliers were rejected at the lower level of concentration, while only one had to be rejected at the higher concentration. Unlike sodium, the results for potassium gave comparable values for precision and accuracy at both concentration levels. The following table presents a comparison of precision and accuracy results from the present study (underlined) with those given in Standard Methods:

Potassium mg/l	No. of results	Rel. standard deviation, %	Relative error, %
2.7	27	14.08	+ 5.47
3.1	33	15.5	2.3
8.4	28	16.81	+ 3.58

As for sodium, the principal probable sources of error in this method are likely to be reduced by more accurate calibration standards and greater attention to instrumental aspects of measurement.

Chloride

The argentometric (Mohr) method, based on the formation of orange-red silver chromate at the end point, was by far the most commonly reported. Two laboratories reported using the Volhard method which involves the addition of excess silver ion and back-titration of the excess silver ion with thiocyanate. Seven laboratories reported using the mercuric nitrate titration method.

All participating laboratories reported results for the analysis of chloride, with four results being rejected at the higher concentration level, and three at the lower level.

Precision was not as good as might be expected, and improvement is certainly possible due to the relative simplicity of the analysis. Accuracy was excellent for the higher concentration level, but only acceptable at the lower level. In the following table results for this study (underlined) are compared with those reported by EPA for a previous study using the mercuric nitrate method:

Reference	Chloride mg/l	No. of laboratories	Precision as Rel. Std. Dev. %	Accuracy as % Rel. error
EPA	17	25	8.85	+ 2.16
CEPIS/PAHO	28.1	55	17.59	+ 6.68
CEPIS/PAHO	86.4	56	13.09	+ 0.91
EPA	91	25	3.21	- 0.11

As in the other titrimetric methods of analysis, errors in measurement are generally related to improper standardization of the titrant solution, failure to correct for the reagent blank, and errors in reading the buret.

Alkalinity

The definition of alkalinity of a water as the quantitative capacity to neutralize a strong acid to a designated pH also defines the method which must be utilized in its determination. Whether sulfuric or hydrochloric acid is used as titrant is irrelevant as long as the acid is properly standardized.

Results for alkalinity determinations were reported by 58 laboratories, of which three were rejected as outliers at the low level and four at the high level.

Precision as relative standard deviation was found to be relatively poor for the lower level concentration, with some improvement at the higher level of concentration. Statistics for accuracy showed a positive bias for both levels of concentration, with the relative error being more significant at the lower level. The following table presents a comparison of performance results for this study (underlined) with those reported in Standard Methods:

Total alkalinity mg/l as $CaCO_3$	No. of laboratories	Precision as Rel. Std. Dev. %	Accuracy as % rel. error
8.0	22	11.66	+ 22.29
9.0	22	12.76	+ 10.61
10.4	55	23.15	+ 24.09
35.7	54	9.11	+ 6.18
113	22	5.10	- 7.42
119	22	4.84	- 8.19

Possible sources of error in measurement of alkalinity include the use of incorrectly standardized sulfuric acid titrant solution, failure to properly correct for the blank, titration to incorrect pH end point, and measurement errors in general.

Fluoride

The most frequently reported (19 laboratories) method for fluoride analysis was the alizarin visual procedure. Eleven laboratories reported employing the SPADNS spectrophotometric procedure, while only five laboratories reported using the electrode method. The remaining laboratories did not

clearly specify which procedures were followed. As for chloride analysis, it appears that laboratories tend to use well-established traditional methods.

Fluoride measurements were carried out by 43 of the 59 participating laboratories, with three results being rejected as outliers at the higher concentration and two at the lower.

Relative standard deviation and relative accuracy were found to be somewhat higher than expected. The following table compares the results for this study (underlined) with those reported in Standard Methods for the SPADNS and Alizarin Visual methods and no interference:

Fluoride mg/l	Method	No. of laboratories	Precision as Rel. Std. Dev. %	Accuracy as percent rel. error
0.2	-	40	38.76	+ 10.38
0.830	SPADNS	53	8.0	1.2
0.830	Alizarin Vis.	20	4.9	3.6
1.1	-	41	16.04	+ 7.43

Sulfate

All but two of the 59 participating laboratories reported results for the analysis of sulfate. No outliers were found for the lower concentration, while two results were rejected at the higher concentration.

The majority (thirty-one) of the laboratories reported using a turbidimetric procedure for sulfate determination. Seventeen laboratories reported using gravimetric procedures, with seven of these indicating that the procedure included ignition of the residue. One laboratory reported using an EDTA procedure, while another used an unspecified benzidine procedure.

Statistical calculations indicated relatively poor precision and negative bias at both levels of concentration. Percent relative error was nearly equal at both levels of concentration.

The following table compares statistical results for the present study (underlined) with those reported by EPA for a previous study using the turbidimetric method:

Sulfate mg/l	No. of laboratories	Precision as Rel. Std. Dev. %	Accuracy as percent rel. error
8.6	25	27.78	- 3.72
9.2	25	21.09	- 8.26
12.0	57	38.61	- 9.47
102.4	55	20.89	- 9.87
110	25	7.35	- 3.01
122	25	6.36	- 3.37

The major source of error in the measurement of sulfate is probably the method itself. There simply is no completely satisfactory standard method for analysis of sulfate. Laboratories with large deviations from the true values however can certainly improve by carefully following procedures for existing standard methods.

* * * * *

Annex I, following, presents the true value, the 95% confidence limits, and the actual laboratory results for each parameter, for the 59 participating laboratories each of them identified by a number. This will permit each laboratory to analyze its own performance and compare it with the others in the study. The code for each laboratory is not included.

Annex II includes the results for each parameter obtained from computer runs. The whole range of results is thus shown as well as the different statistical calculations that follow.

ANNEX I

RESULTS FOR PHYSICAL/MINERAL ANALYSIS

Parameter		pH		Elec. Cond.		T.D.S.		T. Hardness		Calcium		Magnesium		Sodium		Potassium		Tot. Alk.		Chloride		Fluoride		Sulfate	
		#1	#2	#1	#2	#1	#2	#1	#2	#1	#2	#1	#2	#1	#2	#1	#2	#1	#2	#1	#2	#1	#2	#1	#2
True Value		7.7	8.6	157.0	603.0	71.7	318.3	48.6	170.2	14.5	44.5	3.0	14.4	5.0	39.7	2.7	8.4	10.4	35.7	28.1	86.4	0.2	1.1	12.0	102.4
95 % Confidence Limits		6.25 8.11	6.97 8.65	125.9 189.9	481.1 692.4	58.2 178.3	281.0 475.5	42.48 61.16	159.0 194.1	11.86 18.76	35.42 56.74	0.60 6.08	9.19 20.65	1.88 9.60	25.31 55.55	2.02 3.66	5.71 11.69	7.05 18.75	30.82 44.84	19.64 40.30	64.8 109.6	0.06 0.38	0.81 1.55	2.64 19.08	54.5 130.1
Laboratory Code Number	1	7.0	7.7	156.	600.	80.0	297.5	51.5	180.2	13.5	42.0	4.4	18.2	5.1	42.0	2.8	9.0	13.3	39.8	29.6	91.5	0.16	1.32	10.0	100.0
	2	7.7	7.95	150.	560.	150.	393.	51.5	179.7	15.2	48.1	3.3	14.5	6.9	47.1	3.1	10.9	22.5	60.	53.	117.	0.16	1.36	16.	91.
	3	7.05	7.55	142.	567.	97.8	372.6	50.0	172.0	15.0	45.0	3.0	14.0	5.5	39.5	3.0	8.0	10.4	40.5	34.4	96.0	0.20	1.00	9.0	100.0
	4	8.3	8.3	-	-	340.0	470.0	58.0	186.0	-	-	-	-	-	-	-	-	-	-	33.0	93.0	-	-	14.5	97.3
	5	6.25	7.35	-	-	110.0	381.0	53.0	180.0	13.6	39.2	4.6	19.7	-	-	-	-	25.0	78.0	23.0	83.0	0.45	1.30	15.5	106.4
	6	7.40	8.10	-	-	133.0	339.0	64.0	204.0	16.0	52.8	5.8	17.6	23.0	70.7	3.0	10.0	12.0	30.0	34.0	98.0	0.20	1.10	16.2	112.6
	7	7.68	8.22	290.	850.	130.4	357.8	47.2	171.2	15.0	45.7	2.4	13.9	-	-	-	-	12.0	37.0	40.5	66.5	0.15	1.00	11.0	84.0
	8	6.83	7.52	162.	607.	102.	357.	48.8	201.4	17.0	45.0	1.5	21.7	7.1	44.1	3.2	9.7	11.7	38.5	31.1	88.9	-	-	7.6	82.3
	9	7.71	7.70	154.	667.	187.5	473.0	60.0	200.0	10.0	38.9	8.5	24.9	-	-	-	-	10.0	34.0	26.2	87.9	0.10	0.60	14.4	185.2
	10	7.40	7.80	164.	610.	110.0	410.0	51.0	174.8	14.6	46.5	3.8	15.1	5.9	37.3	2.3	8.8	19.5	38.5	30.1	70.9	0.20	1.25	12.0	92.5
	11	7.75	8.25	175.	625.	106.0	406.0	50.7	176.8	16.3	47.7	2.4	13.8	-	-	-	-	10.7	40.0	29.0	73.7	0.20	1.10	15.4	101.6
	12	6.45	7.50	150.	590.	100.	391.	51.	176.	15.2	46.8	3.1	14.2	-	-	-	-	10.	38.8	31.	87.	0.25	1.2	11.9	108.0

RESULTS FOR PHYSICAL/MINERAL ANALYSIS

Parameter		pH		Elec. Cond.		T.D.S.		T. Hardness		Calcium		Magnesium		Sodium		Potassium		Tot. Alk.		Chloride		Fluoride		Sulfate	
		#1	#2	#1	#2	#1	#2	#1	#2	#1	#2	#1	#2	#1	#2	#1	#2	#1	#2	#1	#2	#1	#2	#1	#2
True Value		7.7	8.6	157.0	603.0	71.7	318.3	48.6	170.2	14.5	44.5	3.0	14.4	5.0	39.7	2.7	8.4	10.4	35.7	28.1	86.4	0.2	1.1	12.0	102.4
95 % Confidence Limits		6.25 8.11	6.97 8.65	125.9 189.9	481.1 692.4	58.2 178.3	281.0 475.5	42.48 61.16	159.0 194.1	11.86 18.76	35.42 56.74	0.60 6.08	9.19 20.65	1.88 9.60	25.31 55.55	2.02 3.66	5.71 11.69	7.05 18.75	30.82 44.84	19.64 40.30	64.8 109.6	0.06 0.38	0.81 1.55	2.64 19.08	54.5 130.1
Laboratory Code Number	13	7.17	8.05	-	-	147.5	432.0	50.3	176.2	14.3	44.8	2.7	14.3	4.9	40.5	3.2	10.1	14.5	39.5	30.8	91.5	0.97	0.19	10.7	94.6
	14	6.8	6.9	150.	500.	33.	315.	54.9	172.5	11.	128.	43.9	44.5	-	-	-	-	14.3	43.2	10.1	22.2	0.32	1.7	17.	78.
	15	7.20	7.80	157.	605.	105.0	342.0	50.0	175.0	15.2	46.8	2.9	14.0	4.7	40.3	2.6	9.6	10.0	36.0	28.0	90.0	0.17	1.23	12.0	107.5
	16	6.85	7.43	165.	595.	118.	470.	54.0	184.0	13.6	43.2	4.9	18.5	4.8	36.0	-	-	14.5	39.0	23.5	72.0	0.34	2.75	6.3	106.
	17	7.65	8.3	-	-	118.0	380.0	48.0	180.0	18.0	50.0	1.0	14.0	-	-	-	-	12.0	38.0	30.0	94.0	0.22	1.0	14.0	100.0
	18	7.20	7.90	150.	550.	144.0	388.0	50.0	172.0	14.7	47.0	3.2	13.2	-	-	-	-	13.5	38.0	30.4	90.3	0.20	1.20	-	-
	19	7.5	8.1	-	-	-	-	52.0	175.	38.	112.	3.4	30.2	-	-	-	-	16.	42.0	68.	196.	0.28	1.14	10.	107.0
	20	7.31	8.20	-	-	39.	305.	52.1	175.4	17.0	51.1	2.6	15.0	6.9	44.3	2.4	8.1	16.6	34.6	19.1	74.0	0.2	1.3	13.2	93.6
	21	7.60	7.52	159.	572.	100.	320.	46.0	154.0	13.6	36.8	2.9	12.6	-	-	-	-	11.0	36.0	30.5	85.0	-	-	10.8	96.0
	22	7.30	7.8	158.	615.	180.0	451.	52.0	178.0	-	-	-	-	-	-	-	-	11.4	39.4	30.7	92.1	0.20	1.2	1.7	94.4
	23	7.05	7.64	155.	590.	131.0	405.0	54.0	183.0	13.8	23.8	1.8	5.6	5.3	39.0	2.8	15.8	13.2	41.8	28.0	81.5	0.12	1.25	1.4	100.4
	24	5.1	3.	-	-	0	0	325.	496.	84.	291.	241.	205.	-	-	-	-	42.	58.	8.9	12.1	-	-	6.	7.

RESULTS FOR PHYSICAL/MINERAL ANALYSIS

Parameter		pH		Elec. Cond.		T.D.S.		T. Hardness		Calcium		Magnesium		Sodium		Potassium		Tot. Alk.		Chloride		Fluoride		Sulfate	
		#1	#2	#1	#2	#1	#2	#1	#2	#1	#2	#1	#2	#1	#2	#1	#2	#1	#2	#1	#2	#1	#2	#1	#2
True Value		7.7	8.6	157.0	603.0	71.7	318.3	48.6	170.2	14.5	44.5	3.0	14.4	5.0	39.7	2.7	8.4	10.4	35.7	28.1	86.4	0.2	1.1	12.0	102.4
95 % Confidence Limits		6.25 8.11	6.97 8.65	125.9 189.9	481.1 692.4	58.2 178.3	281.0 475.5	42.48 61.16	159.0 194.1	11.86 18.76	35.42 56.74	0.60 6.08	9.19 20.65	1.88 9.60	25.31 55.55	2.02 3.66	5.71 11.69	7.05 18.75	30.82 44.84	19.64 40.30	64.8 109.6	0.06 0.38	0.81 1.55	2.64 19.08	54.5 130.1
Laboratory Code Number	25	7.45	8.10	162.	620.	100.0	400.0	58.0	190.0	15.2	47.2	4.8	18.0	5.2	37.5	3.0	9.0	17.0	40.0	28.0	85.0	0.33	1.30	7.0	72.0
	26	6.6	7.3	162.	567.	104.5	426.5	96.8	198.8	14.1	40.4	2.7	12.6	5.5	37.2	2.9	8.2	11.4	36.1	32.0	74.5	0.3	0.7	11.5	89.5
	27	7.5	7.0	-	-	-	-	50.	170.	-	-	-	-	-	-	-	-	10.	40.	40.	100.	-	-	12.	40.
	28	6.2	6.70	180.	660.	105.	352.	55.1	172.2	15.2	45.3	4.1	14.3	4.5	47.8	2.5	7.8	14.5	44.5	32.3	83.5	0.20	1.02	11.0	109.5
	29	7.69	8.21	157.	598.	120.	298.	49.4	176.6	14.5	45.4	3.2	15.4	11.8	39.7	2.29	10.91	11.6	35.1	28.5	89.5	0.25	1.4	12.9	89.6
	30	6.5	7.0	-	-	83.	286.	-	-	-	-	-	-	-	-	-	-	20.	60.	20.8	72.4	-	-	7.	38.
	31	7.3	8.0	-	-	-	-	60.0	180.0	16.0	48.0	24.2	14.5	-	-	-	-	8.0	24.5	40.0	100.0	0.6	1.42	10.7	56.2
	32	5.85	6.40	-	-	160.8	395.5	60.0	176.4	16.9	46.7	6.5	14.5	-	-	-	-	25.2	40.5	35.0	72.3	-	-	20.6	112.4
	33	7.70	8.31	151.	543.	136.8	480.2	52.0	180.	16.8	47.6	2.42	16.	9.85	41.1	2.8	8.4	14.	30.	16.	48.	0.2	1.3	10.	100.
	34	6.7	7.4	-	-	132.	416.	47.	181.	16.5	50.	1.3	14.	-	-	-	-	13.	42.	29.	87.	-	-	15.	105.
	35	7.10	7.60	-	-	14.2	43.0	48.0	176.0	16.8	41.6	2.4	14.1	2.0	18.5	2.8	8.7	12.0	38.0	31.0	91.0	-	-	17.0	98.0
	36	7.82	8.50	150.	560.	147.5	341.0	56.4	173.9	15.0	47.0	4.6	13.5	5.6	40.8	3.0	8.6	10.4	36.4	30.0	91.0	0.20	1.08	12.2	104.0

RESULTS FOR PHYSICAL/MINERAL ANALYSIS

Parameter		pH		Elec. Cond.		T.D.S.		T. Hardness		Calcium		Magnesium		Sodium		Potassium		Tot. Alk.		Chloride		Fluoride		Sulfate	
		#1	#2	#1	#2	#1	#2	#1	#2	#1	#2	#1	#2	#1	#2	#1	#2	#1	#2	#1	#2	#1	#2	#1	#2
True Value		7.7	8.6	157.0	603.0	71.7	318.3	48.6	170.2	14.5	44.5	3.0	14.4	5.0	39.7	2.7	8.4	10.4	35.7	28.1	86.4	0.2	1.1	12.0	102.4
95 % Confidence Limits		6.25 8.11	6.97 8.65	125.9 189.9	481.1 692.4	58.2 178.3	281.0 475.5	42.48 61.16	159.0 194.1	11.86 18.76	35.42 56.74	0.60 6.08	9.19 20.65	1.88 9.60	25.31 55.55	2.02 3.66	5.71 11.69	7.05 18.75	30.82 44.84	19.64 40.30	64.8 109.6	0.06 0.38	0.81 1.55	2.64 19.08	54.5 130.1
Laboratory Code Number	37	7.1	7.6	155.	570.	119.	369.	52.	166.	17.	46.	2.	14.	7.	40.	1.	5.	13.	36.	30.	89.	0.20	1.20	11.	98.
	38	7.69	8.53	158.	565.	103.	374.2	50.7	178.1	15.9	47.5	2.7	14.4	4.8	35.5	2.7	9.0	10.8	36.9	29.0	86.0	0.12	1.20	10.1	100.0
	39	7.45	8.25	155.	590.	131.0	392.0	50.9	176.1	14.2	46.2	3.6	14.8	5.8	40.5	2.8	10.0	15.0	40.0	31.0	102.0	0.20	1.00	5.0	90.0
	40	7.90	8.20	500.	1250.	122.0	365.0	52.0	184.0	13.6	46.4	4.4	16.5	-	-	-	-	16.0	40.0	30.0	93.0	-	-	10.5	80.0
	41	6.80	7.80	200.	600.	14.0	383.0	55.0	175.0	18.4	48.0	2.4	13.4	6.2	41.7	2.7	9.4	12.0	38.0	33.0	96.0	0.25	1.00	9.6	53.2
	42	6.45	7.20	152.	563.	120.5	378.0	58.0	176.5	15.6	44.6	4.7	15.9	-	-	-	-	12.0	39.0	31.5	93.5	0.0	1.1	12.5	102.5
	43	7.50	8.26	130.	380.	126.0	396.5	41.0	161.7	15.4	46.8	0.6	10.7	-	-	-	-	11.5	37.0	30.5	90.5	-	-	5.8	50.0
	44	7.35	7.80	157.	596.	115.0	366.5	45.0	160.0	14.8	42.0	3.1	14.5	1.0	10.0	1.0	5.0	9.0	33.0	38.0	102.0	0.36	1.20	19.8	106.5
	45	7.35	8.16	163.	640.	139.	408.	53.8	180.5	16.0	47.4	3.3	14.9	-	-	-	-	12.0	38.0	30.2	90.5	-	-	12.0	92.0
	46	7.59	8.37	110.	290.	121.8	358.0	50.9	179.3	14.5	45.8	3.6	15.8	3.5	33.4	2.8	8.8	11.0	37.4	28.4	87.6	0.25	1.30	7.0	97.1
	47	7.20	8.10	191.	706.	117.0	372.0	56.0	168.0	15.2	45.6	4.4	13.1	5.5	46.0	4.0	10.0	10.2	37.8	35.6	94.9	-	-	3.1	45.8
	48	7.35	7.8	166.	590.	128.	396.	50.	175.	15.2	50.9	2.9	11.4	-	-	-	-	20.	34.	33.9	93.6	0.15	1.3	15.1	101.0

RESULTS FOR PHYSICAL/MINERAL ANALYSIS

Parameter		pH		Elec. Cond.		T.D.S.		T. Hardness		Calcium		Magnesium		Sodium		Potassium		Tot. Alk.		Chloride		Fluoride		Sulfate	
		#1	#2	#1	#2	#1	#2	#1	#2	#1	#2	#1	#2	#1	#2	#1	#2	#1	#2	#1	#2	#1	#2	#1	#2
True Value		7.7	8.6	157.0	603.0	71.7	318.3	48.6	170.2	14.5	44.5	3.0	14.4	5.0	39.7	2.7	8.4	10.4	35.7	28.1	86.4	0.2	1.1	12.0	102.4
95 % Confidence Limits		6.25 8.11	6.97 8.65	125.9 189.9	481.1 692.4	58.2 178.3	281.0 475.5	42.48 61.16	159.0 194.1	11.86 18.76	35.42 56.74	0.60 6.08	9.19 20.65	1.88 9.60	25.31 55.55	2.02 3.66	5.71 11.69	7.05 18.75	30.82 44.84	19.64 40.30	64.8 109.6	0.06 0.38	0.81 1.55	2.64 19.08	54.3 130.1
Laboratory Code Number	49	6.55	7.10	150.	595.	100.0	379.0	46.5	162.7	14.3	47.1	2.5	10.9	-	-	-	-	10.6	36.8	30.7	90.4	0.10	1.16	11.0	117.0
	50	7.25	7.90	142.	540.	91.0	351.5	50.0	177.0	14.8	48.0	3.1	13.9	7.5	38.0	2.0	6.0	10.9	35.7	29.0	88.0	0.20	1.20	11.	110.
	51	6.9	7.7	191.	656.	123.	379.	35.8	179.	15.	45.7	3.5	14.	5.	40.	3.	9.	10.	38.	12.	72.	0.20	1.30	2.9	97.9
	52	6.98	8.00	-	-	-	-	54.2	162.5	21.7	65.1	-	-	-	-	-	-	15.0	42.0	35.3	56.5	-	-	-	-
	53	7.02	7.85	-	-	79.0	305.	51.7	176.7	13.8	37.4	4.2	20.0	5.4	36.0	3.0	8.3	10.8	34.0	21.	90.	.25	1.10	4.9	92.9
	54	6.70	7.50	137.	229.	91.0	345.0	49.0	174.0	15.3	48.6	2.8	14.0	6.2	40.7	2.6	7.8	14.0	40.0	30.9	89.0	-	-	16.0	110.3
	55	7.68	8.57	-	-	190.	426.	51.1	175.4	17.4	45.8	1.5	14.6	-	-	-	-	10.	36.	31.8	95.4	0.4	1.2	9.	100.
	56	7.1	7.8	-	-	170.8	492.0	54.32	177.77	15.81	45.43	3.55	15.95	29.65	81.39	-	-	11.0	35.0	32.0	92.0	0.25	1.32	7.0	62.0
	57	6.73	7.36	-	-	135.0	310.0	45.5	158.6	28.1	56.1	-	-	-	-	-	-	14.5	43.5	26.6	86.9	-	-	10.0	120.0
	58	7.10	7.90	158.	560.	97.0	308.0	56.0	180.0	16.8	49.6	3.4	13.6	6.1	36.5	-	-	13.0	42.0	32.0	94.0	0.60	1.40	11.0	82.1
	59	7.40	8.10	177.	671.	100.0	340.0	56.8	187.0	15.9	50.0	4.9	18.0	6.8	41.2	3.6	9.5	16.5	41.2	30.8	91.5	0.30	1.00	11.4	99.5

ANNEX II

PARAMETRO (PARAMETER)	=	UNIDADES PH I (PH UNITS I)
N, DATOS TOTALES (N, ALL DATA)	=	59
NUMERO DATOS RECHAZADOS (NUMBER OF DATA REJECTED)	=	1
VALOR VERDADERO (TRUE VALUE)	=	7.70
PROMEDIO (MEAN)	=	7.18
MEDIANA (MEDIAN)	=	7.22
ERROR REL. % (PCT REL ERROR)	=	-6.69
AMPLITUD (RANGE)	=	2.45
VARIANZA (VARIANCE)	=	0.22
DESV. ESTANDAR (STD.DEV)	=	0.47
LIMITES DE CONFIANZA 95% (CONF.LIMITS ,95%)	=	±0.93
COEF. DE VARIACION % (COEFF. VARIANCE %)	=	6.62
ASIMETRIA (SKEWNESS)	=	-0.46

INTERVALO			HISTOGRAMA
5.85	-	6.14	*
6.15	-	6.45	****
6.46	-	6.75	******
6.76	-	7.06	**********
7.07	-	7.37	**********
7.38	-	7.67	**********
7.68	-	7.98	********
7.99	-	8.30	*

DATOS EN ORDEN ASCENDENTE
(DATA IN ASCENDING ORDER)

5.1 R2	7.31
5.85	7.35
6.2	7.35
6.25	7.35
6.45	7.4
6.45	7.4
6.5	7.4
6.55	7.45
6.6	7.45
6.7	7.5
6.7	7.5
6.73	7.5
6.8	7.59
6.8	7.6
6.83	7.65
6.85	7.68
6.9	7.68
6.98	7.69
7	7.69
7.02	7.7
7.05	7.7
7.05	7.71
7.1	7.75
7.1	7.82
7.1	7.9
7.1	8.3
7.17	
7.2	
7.2	
7.2	
7.25	
7.3	
7.3	

R1=DATO RECHAZADO, 4 DESV.ESTAND.
(REJECTED DATA, 4 STD.DEV)
R2=DATO RECHAZADO, PRUEBA T
(REJECTED DATA, t-test)

PARAMETRO (PARAMETER)	=	UNIDADES PH II (PH UNITS II)
N, DATOS TOTALES (N, ALL DATA)	=	59
NUMERO DATOS RECHAZADOS (NUMBER OF DATA REJECTED)	=	2
VALOR VERDADERO (TRUE VALUE)	=	8.60
PROMEDIO (MEAN)	=	7.81
MEDIANA (MEDIAN)	=	7.80
ERROR REL. % (PCT REL ERROR)	=	-9.10
AMPLITUD (RANGE)	=	1.87
VARIANZA (VARIANCE)	=	0.18
DESV. ESTANDAR (STD.DEV)	=	0.43
LIMITES DE CONFIANZA 95% (CONF.LIMITS ,95%)	=	±0.84
COEF. DE VARIACION % (COEFF. VARIANCE %)	=	5.50
ASIMETRIA (SKEWNESS)	=	-0.50

INTERVALO			HISTOGRAMA
6.70	-	6.92	**
6.93	-	7.15	***
7.16	-	7.39	*****
7.40	-	7.62	********
7.63	-	7.85	**********
7.86	-	8.09	**********
8.10	-	8.32	**********
8.33	-	8.57	****

DATOS EN ORDEN ASCENDENTE
(DATA IN ASCENDING ORDER)

3 R1	7.9
6.4 R2	7.9
6.7	7.95
6.9	8
7	8
7	8.05
7.1	8.1
7.2	8.1
7.3	8.1
7.35	8.1
7.36	8.1
7.4	8.16
7.43	8.2
7.5	8.2
7.5	8.21
7.52	8.22
7.52	8.25
7.55	8.25
7.6	8.26
7.6	8.3
7.64	8.3
7.7	8.31
7.7	8.37
7.7	8.5
7.8	8.53
7.8	8.57
7.8	
7.8	
7.8	
7.8	
7.8	
7.85	
7.9	

R1=DATO RECHAZADO, 4 DESV.ESTAND.
(REJECTED DATA, 4 STD.DEV)
R2=DATO RECHAZADO, PRUEBA T.
(REJECTED DATA, t-test)

PARAMETRO (PARAMETER)	=	CONDUCTANCIA I (CONDUCTANCE I)
N, DATOS TOTALES (N, ALL DATA)	=	40
NUMERO DATOS RECHAZADOS (NUMBER OF DATA REJECTED)	=	2
VALOR VERDADERO (TRUE VALUE)	=	157.00
PROMEDIO (MEAN)	=	157.92
MEDIANA (MEDIAN)	=	157.00
ERROR REL. % (PCT REL ERROR)	=	0.58
AMPLITUD (RANGE)	=	90.00
VARIANZA (VARIANCE)	=	266.45
DESV. ESTANDAR (STD.DEV)	=	16.32
LIMITES DE CONFIANZA 95% (CONF.LIMITS ,95%)	=	±31.99
COEF. DE VARIACION % (COEFF. VARIANCE %)	=	10.33
ASIMETRIA (SKEWNESS)	=	0.12

INTERVALO			HISTOGRAMA
110.00	-	121.24	*
121.25	-	132.49	*
132.50	-	143.74	***
143.75	-	154.99	*********
155.00	-	166.24	******************
166.25	-	177.49	**
177.50	-	188.74	*
188.75	-	200.00	***

DATOS EN ORDEN ASCENDENTE
(DATA IN ASCENDING ORDER)

110	177
130	180
137	191
142	191
142	200
150	290 R2
150	500 R1
150	
150	
150	
150	
151	
152	
154	
155	
155	
155	
156	
157	
157	
157	
158	
158	
158	
159	
162	
162	
162	
163	
164	
165	
166	
175	

R1=DATO RECHAZADO, 4 DESV.ESTAND.
(REJECTED DATA, 4 STD.DEV)
R2=DATO RECHAZADO, PRUEBA T
(REJECTED DATA, t-test)

PARAMETRO (PARAMETER)	=	CONDUCTANCIA II (CONDUCTANCE II)
N, DATOS TOTALES (N, ALL DATA)	=	40
NUMERO DATOS RECHAZADOS (NUMBER OF DATA REJECTED)	=	4
VALOR VERDADERO (TRUE VALUE)	=	603.00
PROMEDIO (MEAN)	=	586.75
MEDIANA (MEDIAN)	=	590.00
ERROR REL. % (PCT.REL ERROR)	=	-2.69
AMPLITUD (RANGE)	=	326.00
VARIANZA (VARIANCE)	=	2905.16
DESV. ESTANDAR (STD.DEV)	=	53.89
LIMITES DE CONFIANZA 95% (CONF.LIMITS ,95%)	=	±105.64
COEF. DE VARIACION % (COEFF. VARIANCE %)	=	9.18
ASIMETRIA (SKEWNESS)	=	-1.23

INTERVALO			HISTOGRAMA
380.00	-	420.74	*
420.75	-	461.49	
461.50	-	502.24	*
502.25	-	542.99	*
543.00	-	583.74	**********
583.75	-	624.49	**********
624.50	-	665.24	***
665.25	-	706.00	***

DATOS EN ORDEN ASCENDENTE
(DATA IN ASCENDING ORDER)

229 R2	640
290 R2	656
380	667
500	671
540	706
543	850 R2
550	1250 R1
560	
560	
560	
560	
563	
565	
567	
567	
570	
572	
590	
590	
590	
590	
595	
595	
596	
598	
600	
600	
605	
607	
610	
615	
620	
625	

R1=DATO RECHAZADO, 4 DESV.ESTAND.
(REJECTED DATA, 4 STD.DEV)
R2=DATO RECHAZADO, PRUEBA T
(REJECTED DATA, t-test)

PARAMETRO (PARAMETER)	=	SOLIDOS TOT.DIS I (TOT.DISS. SOLIDS I)
N, DATOS TOTALES (N, ALL DATA)	=	54
NUMERO DATOS RECHAZADOS (NUMBER OF DATA REJECTED)	=	3
VALOR VERDADERO (TRUE VALUE)	=	71.70
PROMEDIO (MEAN)	=	118.25
MEDIANA (MEDIAN)	=	118.00
ERROR REL. % (PCT REL ERROR)	=	64.92
AMPLITUD (RANGE)	=	157.00
VARIANZA (VARIANCE)	=	940.16
DESV. ESTANDAR (STD.DEV)	=	30.66
LIMITES DE CONFIANZA 95% (CONF.LIMITS ,95%)	=	±60.09
COEF. DE VARIACION % (COEFF. VARIANCE %)	=	25.92
ASIMETRIA (SKEWNESS)	=	-0.06

INTERVALO			HISTOGRAMA
33.00	-	52.61	**
52.62	-	72.24	
72.25	-	91.86	*****
91.87	-	111.49	**********
111.50	-	131.11	**********
131.12	-	150.74	*********
150.75	-	170.36	*
170.37	-	190.00	****

DATOS EN ORDEN ASCENDENTE
(DATA IN ASCENDING ORDER)

14 R2	123
14.2 R2	126
33	128
39	130.4
79	131
80	131
83	132
91	133
91	135
97	136.8
97.8	139
100	144
100	147.5
100	147.5
100	150
100	160.8
102	170.8
103	180
104.5	187.5
105	190
105	340 R1
106	
110	
110	
115	
117	
118	
118	
119	
120	
120.5	
121.8	
122	

R1=DATO RECHAZADO, 4 DESV.ESTANC
(REJECTED DATA, 4 STD.DEV)
R2=DATO RECHAZADO, PRUEBA T
(REJECTED DATA, t-test)

PARAMETRO (PARAMETER)	=	SOLIDOS TOT.DIS. II (TOT.DISS. SOLIDS II)
N, DATOS TOTALES (N, ALL DATA)	=	54
NUMERO DATOS RECHAZADOS (NUMBER OF DATA REJECTED)	=	1
VALOR VERDADERO (TRUE VALUE)	=	318.30
PROMEDIO (MEAN)	=	378.20
MEDIANA (MEDIAN)	=	379.00
ERROR REL. % (PCT REL ERROR)	=	18.81
AMPLITUD (RANGE)	=	206.00
VARIANZA (VARIANCE)	=	2462.07
DESV. ESTANDAR (STD.DEV)	=	49.61
LIMITES DE CONFIANZA 95% (CONF.LIMITS ,95%)	=	±97.25
COEF. DE VARIACION % (COEFF. VARIANCE %)	=	13.11
ASIMETRIA (SKEWNESS)	=	0.30

INTERVALO			HISTOGRAMA
286.00	-	311.74	*******
311.75	-	337.49	**
337.50	-	363.24	**********
363.25	-	388.99	**********
389.00	-	414.74	**********
414.75	-	440.49	****
440.50	-	466.24	*
466.25	-	492.00	*****

DATOS EN ORDEN ASCENDENTE
(DATA IN ASCENDING ORDER)

43 R1	391
286	392
297.5	393
298	395.5
305	396
305	396.5
308	400
310	405
315	406
320	408
339	410
340	416
341	426
342	426.5
345	432
351.5	451
352	470
357	470
357.8	473
358	480.2
365	492
366.5	
369	
372	
372.6	
374.2	
378	
379	
379	
380	
381	
383	
388	

R1=DATO RECHAZADO, 4 DESV.ESTAND.
(REJECTED DATA, 4 STD.DEV)
R2=DATO RECHAZADO, PRUEBA T
(REJECTED DATA, t-test)

PARAMETRO (PARAMETER)	=	DUREZA TOT. I (TOT.HARDNESS I)
N, DATOS TOTALES (N, ALL DATA)	=	58
NUMERO DATOS RECHAZADOS (NUMBER OF DATA REJECTED)	=	2
VALOR VERDADERO (TRUE VALUE)	=	48.60
PROMEDIO (MEAN)	=	51.82
MEDIANA (MEDIAN)	=	51.50
ERROR REL. % (PCT REL ERROR)	=	6.63
AMPLITUD (RANGE)	=	28.20
VARIANZA (VARIANCE)	=	22.71
DESV. ESTANDAR (STD.DEV)	=	4.76
LIMITES DE CONFIANZA 95% (CONF.LIMITS ,95%)	=	±9.34
COEF. DE VARIACION % (COEFF. VARIANCE %)	=	9.19
ASIMETRIA (SKEWNESS)	=	-0.35

INTERVALO			HISTOGRAMA
35.80	-	39.31	*
39.32	-	42.84	*
42.85	-	46.36	***
46.37	-	49.89	********
49.90	-	53.41	**************************
53.42	-	56.94	************
56.95	-	60.46	******
60.47	-	64.00	*

DATOS EN ORDEN ASCENDENTE
(DATA IN ASCENDING ORDER)

35.8	52
41	52
45	52.1
45.5	53
46	53.8
46.5	54
47	54
47.2	54.2
48	54.32
48	54.9
48.8	55
49	55.1
49.4	56
50	56
50	56.4
50	56.8
50	58
50	58
50	58
50.3	60
50.7	60
50.7	60
50.9	64
50.9	96.8 R2
51	325 R1
51	
51.1	
51.5	
51.5	
51.7	
52	
52	
52	

R1=DATO RECHAZADO, 4 DESV.ESTAND.
(REJECTED DATA, 4 STD.DEV)
R2=DATO RECHAZADO, PRUEBA T
(REJECTED DATA, t-test)

PARAMETRO (PARAMETER)	= DUREZA TOT. II (TOT.HARDNESS II)
N, DATOS TOTALES (N, ALL DATA)	= 58
NUMERO DATOS RECHAZADOS (NUMBER OF DATA REJECTED)	= 2
VALOR VERDADERO (TRUE VALUE)	= 170.20
PROMEDIO (MEAN)	= 176.58
MEDIANA (MEDIAN)	= 176.45
ERROR REL. % (PCT REL ERROR)	= 3.75
AMPLITUD (RANGE)	= 47.40
VARIANZA (VARIANCE)	= 80.16
DESV. ESTANDAR (STD.DEV)	= 8.95
LIMITES DE CONFIANZA 95% (CONF.LIMITS ,95%)	= ±17.54
COEF. DE VARIACION % (COEFF. VARIANCE %)	= 5.07
ASIMETRIA (SKEWNESS)	= 0.30

INTERVALO			HISTOGRAMA
154.00	-	159.91	**
159.92	-	165.84	****
165.85	-	171.76	****
171.77	-	177.69	**********
177.70	-	183.61	**********
183.62	-	189.54	****
189.55	-	195.46	*
195.47	-	201.40	***

DATOS EN ORDEN ASCENDENTE
(DATA IN ASCENDING ORDER)

154	177.77
158.6	178
160	178.1
161.7	179
162.5	179.3
162.7	179.7
166	180
168	180
170	180
171.2	180
172	180
172	180.2
172.2	180.5
172.5	181
173.9	183
174	184
174.8	184
175	186
175	187
175	190
175	198.8
175.4	200
175.4	201.4
176	204 R2
176	496 R1
176.1	
176.2	
176.4	
176.5	
176.6	
176.7	
176.8	
177	

R1=DATO RECHAZADO, 4 DESV.ESTAND.
(REJECTED DATA, 4 STD.DEV)
R2=DATO RECHAZADO, PRUEBA T
(REJECTED DATA, t-test)

PARAMETRO (PARAMETER)	=	CALCIO I (CALCIUM I)
N, DATOS TOTALES (N, ALL DATA)	=	55
NUMERO DATOS RECHAZADOS (NUMBER OF DATA REJECTED)	=	3
VALOR VERDADERO (TRUE VALUE)	=	14.50
PROMEDIO (MEAN)	=	15.31
MEDIANA (MEDIAN)	=	15.20
ERROR REL. % (PCT REL ERROR)	=	5.59
AMPLITUD (RANGE)	=	11.70
VARIANZA (VARIANCE)	=	3.11
DESV. ESTANDAR (STD.DEV)	=	1.76
LIMITES DE CONFIANZA 95% (CONF.LIMITS ,95%)	=	±3.45
COEF. DE VARIACION % (COEFF. VARIANCE %)	=	11.52
ASIMETRIA (SKEWNESS)	=	0.30

INTERVALO			HISTOGRAMA
10.00	-	11.45	**
11.46	-	12.91	
12.92	-	14.37	**********
14.38	-	15.84	**********
15.85	-	17.30	**********
17.31	-	18.76	***
18.77	-	20.22	
20.23	-	21.70	*

DATOS EN ORDEN ASCENDENTE
(DATA IN ASCENDING ORDER)

10	15.81
11	15.9
13.5	15.9
13.6	16
13.6	16
13.6	16
13.6	16.3
13.8	16.5
13.8	16.8
14.1	16.8
14.2	16.8
14.3	16.9
14.3	17
14.5	17
14.5	17
14.6	17.4
14.7	18
14.8	18.4
14.8	21.7
15	28.1 R2
15	38 R2
15	84 R1
15	
15.2	
15.2	
15.2	
15.2	
15.2	
15.2	
15.2	
15.2	
15.3	
15.4	
15.6	

R1=DATO RECHAZADO, 4 DESV.ESTAND.
(REJECTED DATA, 4 STD.DEV)
R2=DATO RECHAZADO, PRUEBA T
(REJECTED DATA, t-test)

PARAMETRO (PARAMETER)	=	CALCIO II (CALCIUM II)
N, DATOS TOTALES (N, ALL DATA)	=	55
NUMERO DATOS RECHAZADOS (NUMBER OF DATA REJECTED)	=	3
VALOR VERDADERO (TRUE VALUE)	=	44.50
PROMEDIO (MEAN)	=	46.08
MEDIANA (MEDIAN)	=	46.60
ERROR REL. % (PCT REL ERROR)	=	3.56
AMPLITUD (RANGE)	=	41.30
VARIANZA (VARIANCE)	=	29.60
DESV. ESTANDAR (STD.DEV)	=	5.44
LIMITES DE CONFIANZA 95% (CONF.LIMITS ,95%)	=	±10.66
COEF. DE VARIACION % (COEFF. VARIANCE %)	=	11.80
ASIMETRIA (SKEWNESS)	=	-0.62

INTERVALO			HISTOGRAMA
23.80	-	28.95	*
28.96	-	34.11	
34.12	-	39.27	****
39.28	-	44.44	*****
44.45	-	49.60	**********
49.61	-	54.76	******
54.77	-	59.92	*
59.93	-	65.10	*

DATOS EN ORDEN ASCENDENTE
(DATA IN ASCENDING ORDER)

23.8	47.2
36.8	47.4
37.4	47.5
38.9	47.6
39.2	47.7
40.4	48
41.6	48
42	48
42	48.1
43.2	48.6
44.6	49.6
44.8	50
45	50
45	50
45.3	50.9
45.4	51.1
45.43	52.8
45.6	56.1
45.7	65.1
45.7	112 R2
45.8	128 R2
45.8	291 R1
46	
46.2	
46.4	
46.5	
46.7	
46.8	
46.8	
46.8	
47	
47	
47.1	

R1=DATO RECHAZADO, 4 DESV.ESTAND.
(REJECTED DATA, 4 STD.DEV)
R2=DATO RECHAZADO, PRUEBA T
(REJECTED DATA, t-test)

PARAMETRO (PARAMETER)	=	MAGNESIO I (MAGNESIUM I)
N, DATOS TOTALES (N, ALL DATA)	=	53
NUMERO DATOS RECHAZADOS (NUMBER OF DATA REJECTED)	=	3
VALOR VERDADERO (TRUE VALUE)	=	3.00
PROMEDIO (MEAN)	=	3.34
MEDIANA (MEDIAN)	=	3.15
ERROR REL. % (PCT REL ERROR)	=	11.58
AMPLITUD (RANGE)	=	7.90
VARIANZA (VARIANCE)	=	1.95
DESV. ESTANDAR (STD.DEV)	=	1.39
LIMITES DE CONFIANZA 95% (CONF.LIMITS ,95%)	=	±2.74
COEF. DE VARIACION % (COEFF. VARIANCE %)	=	41.80
ASIMETRIA (SKEWNESS)	=	1.06

INTERVALO			HISTOGRAMA
0.60	-	1.57	*****
1.58	-	2.56	********
2.57	-	3.55	**********
3.56	-	4.54	********
4.55	-	5.52	******
5.53	-	6.51	**
6.52	-	7.50	
7.51	-	8.50	*

DATOS EN ORDEN ASCENDENTE
(DATA IN ASCENDING ORDER)

.6	3.6
1	3.6
1.3	3.8
1.5	4.1
1.5	4.2
1.8	4.4
2	4.4
2.4	4.4
2.4	4.6
2.4	4.6
2.4	4.7
2.42	4.8
2.5	4.9
2.6	4.9
2.7	5.8
2.7	6.5
2.7	8.5
2.8	24.2 R2
2.9	43.9 R2
2.9	241 R1
2.9	
3	
3.1	
3.1	
3.1	
3.2	
3.2	
3.3	
3.3	
3.4	
3.4	
3.5	
3.55	

R1=DATO RECHAZADO, 4 DESV.ESTAND.
(REJECTED DATA, 4 STD.DEV)
R2=DATO RECHAZADO, PRUEBA T
(REJECTED DATA, t-test)

PARAMETRO (PARAMETER)	=	MAGNESIO II (MAGNESIUM II)
N, DATOS TOTALES (N, ALL DATA)	=	53
NUMERO DATOS RECHAZADOS (NUMBER OF DATA REJECTED)	=	3
VALOR VERDADERO (TRUE VALUE)	=	14.40
PROMEDIO (MEAN)	=	14.92
MEDIANA (MEDIAN)	=	14.35
ERROR REL. % (PCT REL ERROR)	=	3.61
AMPLITUD (RANGE)	=	19.30
VARIANZA (VARIANCE)	=	8.55
DESV. ESTANDAR (STD.DEV)	=	2.92
LIMITES DE CONFIANZA 95% (CONF.LIMITS ,95%)	=	±5.73
COEF. DE VARIACION % (COEFF. VARIANCE %)	=	19.60
ASIMETRIA (SKEWNESS)	=	0.56

INTERVALO			HISTOGRAMA
5.60	-	8.00	*
8.01	-	10.41	
10.42	-	12.82	*****
12.83	-	15.24	**********
15.25	-	17.65	*******
17.66	-	20.06	******
20.07	-	22.47	*
22.48	-	24.90	*

DATOS EN ORDEN ASCENDENTE
(DATA IN ASCENDING ORDER)

5.6	15
10.7	15.1
10.9	15.4
11.4	15.8
12.6	15.9
12.6	15.95
13.1	16
13.2	16.5
13.4	17.6
13.5	18
13.6	18
13.8	18.2
13.9	18.5
13.9	19.7
14	20
14	21.7
14	24.9
14	30.2 R2
14	44.5 R2
14	205 R1
14	
14.1	
14.2	
14.3	
14.3	
14.4	
14.5	
14.5	
14.5	
14.5	
14.6	
14.8	
14.9	

R1=DATO RECHAZADO, 4 DESV.ESTAND.
(REJECTED DATA, 4 STD.DEV)
R2=DATO RECHAZADO, PRUEBA T
(REJECTED DATA, t-test)

PARAMETRO (PARAMETER)	=	SODIO I (SODIUM I)
N, DATOS TOTALES (N, ALL DATA)	=	32
NUMERO DATOS RECHAZADOS (NUMBER OF DATA REJECTED)	=	2
VALOR VERDADERO (TRUE VALUE)	=	5.00
PROMEDIO (MEAN)	=	5.74
MEDIANA (MEDIAN)	=	5.50
ERROR REL. % (PCT REL ERROR)	=	14.90
AMPLITUD (RANGE)	=	10.80
VARIANZA (VARIANCE)	=	3.89
DESV. ESTANDAR (STD.DEV)	=	1.97
LIMITES DE CONFIANZA 95% (CONF.LIMITS ,95%)	=	±3.86
COEF. DE VARIACION % (COEFF. VARIANCE %)	=	34.33
ASIMETRIA (SKEWNESS)	=	0.61

INTERVALO			HISTOGRAMA
1.00	-	2.34	**
2.35	-	3.69	*
3.70	-	5.04	******
5.05	-	6.39	**********
6.40	-	7.74	******
7.75	-	9.09	
9.10	-	10.44	*
10.45	-	11.80	*

DATOS EN ORDEN ASCENDENTE
(DATA IN ASCENDING ORDER)

1
2
3.5
4.5
4.7
4.8
4.8
4.9
5
5.1
5.2
5.3
5.4
5.5
5.5
5.5
5.6
5.8
5.9
6.1
6.2
6.2
6.8
6.9
6.9
7
7.1
7.5
9.85
11.8
23 R2
29.65 R1

R1=DATO RECHAZADO, 4 DESV.ESTAND.
(REJECTED DATA, 4 STD.DEV)
R2=DATO RECHAZADO, PRUEBA T
(REJECTED DATA, t-test)

PARAMETRO (PARAMETER)	=	SODIO II (SODIUM II)
N_a DATOS TOTALES (N, ALL DATA)	=	32
NUMERO DATOS RECHAZADOS (NUMBER OF DATA REJECTED)	=	2
VALOR VERDADERO (TRUE VALUE)	=	39.70
PROMEDIO (MEAN)	=	40.43
MEDIANA (MEDIAN)	=	40.15
ERROR REL. % (PCT REL ERROR)	=	1.83
AMPLITUD (RANGE)	=	52.20
VARIANZA (VARIANCE)	=	59.57
DESV. ESTANDAR (STD.DEV)	=	7.71
LIMITES DE CONFIANZA 95% (CONF.LIMITS ,95%)	=	±15.12
COEF. DE VARIACION % (COEFF. VARIANCE %)	=	19.09
ASIMETRIA (SKEWNESS)	=	1.39

INTERVALO			HISTOGRAMA
18.50	-	25.01	*
25.02	-	31.54	
31.55	-	38.06	*********
38.07	-	44.59	**********
44.60	-	51.11	***
51.12	-	57.64	
57.65	-	64.16	
64.17	-	70.70	*

DATOS EN ORDEN ASCENDIENTE
(DATA IN ASCENDING ORDER)

10 R2
18.5
33.4
35.5
36
36
36.5
37.2
37.3
37.5
38
39
39.5
39.7
40
40
40.3
40.5
40.5
40.7
40.8
41.1
41.2
41.7
42
44.1
44.3
46
47.1
47.8
70.7
81.39 R2

R1=DATO RECHAZADO, 4 DESV.ESTAND.
(REJECTED DATA, 4 STD.DEV)
R2=DATO RECHAZADO, PRUEBA T
(REJECTED DATA, t-test)

PARAMETRO (PARAMETER)	=	POTASIO I (POTASSIUM I)
N, DATOS TOTALES (N, ALL DATA)	=	29
NUMERO DATOS RECHAZADOS (NUMBER OF DATA REJECTED)	=	2
VALOR VERDADERO (TRUE VALUE)	=	2.70
PROMEDIO (MEAN)	=	2.84
MEDIANA (MEDIAN)	=	2.80
ERROR REL. % (PCT REL ERROR)	=	5.47
AMPLITUD (RANGE)	=	2.00
VARIANZA (VARIANCE)	=	0.16
DESV. ESTANDAR (STD.DEV)	=	0.40
LIMITES DE CONFIANZA 95% (CONF.LIMITS ,95%)	=	±0.82
COEF. DE VARIACION % (COEFF. VARIANCE %)	=	14.07
ASIMETRIA (SKEWNESS)	=	0.62

INTERVALO			HISTOGRAMA
2.00	-	2.24	*
2.25	-	2.49	***
2.50	-	2.74	*****
2.75	-	2.99	*******
3.00	-	3.24	*********
3.25	-	3.49	
3.50	-	3.74	*
3.75	-	4.00	*

DATOS EN ORDEN ASCENDENTE
(DATA IN ASCENDING ORDER)

1 R2
1 R2
2
2.29
2.3
2.4
2.5
2.6
2.6
2.7
2.7
2.8
2.8
2.8
2.8
2.8
2.8
2.9
3
3
3
3
3
3
3.1
3.2
3.2
3.6
4

R1=DATO RECHAZADO, 4 DESV.ESTAND.
(REJECTED DATA, 4 STD.DEV)
R2=DATO RECHAZADO, PRUEBA T
(REJECTED DATA, t-test)

PARAMETRO (PARAMETER)	=	POTASIO II (POTASSIUM II)
N, DATOS TOTALES (N, ALL DATA)	=	29
NUMERO DATOS RECHAZADOS (NUMBER OF DATA REJECTED)	=	1
VALOR VERDADERO (TRUE VALUE)	=	8.40
PROMEDIO (MEAN)	=	8.70
MEDIANA (MEDIAN)	=	8.90
ERROR REL. % (PCT REL ERROR)	=	3.57
AMPLITUD (RANGE)	=	5.91
VARIANZA (VARIANCE)	=	2.13
DESV. ESTANDAR (STD.DEV)	=	1.46
LIMITES DE CONFIANZA 95% (CONF.LIMITS ,95%)	=	±2.99
COEF. DE VARIACION % (COEFF. VARIANCE %)	=	16.80
ASIMETRIA (SKEWNESS)	=	-1.14

INTERVALO			HISTOGRAMA
5.00	-	5.72	**
5.73	-	6.46	*
6.47	-	7.20	
7.21	-	7.94	**
7.95	-	8.68	******
8.69	-	9.42	********
9.43	-	10.16	*******
10.17	-	10.91	**

DATOS EN ORDEN ASCENDENTE
(DATA IN ASCENDING ORDER)

5
5
6
7.8
7.8
8
8.1
8.2
8.3
8.4
8.6
8.7
8.8
8.8
9
9
9
9
9.4
9.5
9.6
9.7
10
10
10
10.1
10.9
10.91
15.8 R2

R1=DATO RECHAZADO, 4 DESV.ESTAND.
(REJECTED DATA, 4 STD.DEV)
R2=DATO RECHAZADO, PRUEBA T
(REJECTED DATA, t-test)

PARAMETRO (PARAMETER)	=	ALCALINIDAD TOT. I (TOT.ALKALINITY I)
N, DATOS TOTALES (N, ALL DATA)	=	58
NUMERO DATOS RECHAZADOS (NUMBER OF DATA REJECTED)	=	3
VALOR VERDADERO (TRUE VALUE)	=	10.40
PROMEDIO (MEAN)	=	12.90
MEDIANA (MEDIAN)	=	12.00
ERROR REL. % (PCT REL ERROR)	=	24.09
AMPLITUD (RANGE)	=	14.50
VARIANZA (VARIANCE)	=	8.92
DESV. ESTANDAR (STD.DEV)	=	2.98
LIMITES DE CONFIANZA 95% (CONF.LIMITS ,95%)	=	±5.85
COEF. DE VARIACION % (COEFF. VARIANCE %)	=	23.14
ASIMETRIA (SKEWNESS)	=	1.21

INTERVALO			HISTOGRAMA
8.00	-	9.80	**
9.81	-	11.61	**********
11.62	-	13.42	**********
13.43	-	15.24	**********
15.25	-	17.05	*****
17.06	-	18.86	
18.87	-	20.67	***
20.68	-	22.50	*

DATOS EN ORDEN ASCENDENTE
(DATA IN ASCENDING ORDER)

8	13
9	13.2
10	13.3
10	13.5
10	14
10	14
10	14.3
10	14.5
10.2	14.5
10.4	14.5
10.4	14.5
10.6	15
10.7	15
10.8	16
10.8	16
10.9	16.5
11	16.6
11	17
11	19.5
11.4	20
11.4	20
11.5	22.5
11.6	25 R2
11.7	25.2 R2
12	42 R1
12	
12	
12	
12	
12	
12	
13	
13	

R1=DATO RECHAZADO, 4 DESV.ESTAND.
(REJECTED DATA, 4 STD.DEV)
R2=DATO RECHAZADO, PRUEBA T
(REJECTED DATA, t-test)

PARAMETRO (PARAMETER)	=	ALCALINIDAD TOT. II (TOT.ALKALINITY II)
N_o DATOS TOTALES (N_o ALL DATA)	=	58
NUMERO DATOS RECHAZADOS (NUMBER OF DATA REJECTED)	=	4
VALOR VERDADERO (TRUE VALUE)	=	35.70
PROMEDIO (MEAN)	=	37.83
MEDIANA (MEDIAN)	=	38.00
ERROR REL. % (PCT REL ERROR)	=	5.97
AMPLITUD (RANGE)	=	20.00
VARIANZA (VARIANCE)	=	12.80
DESV. ESTANDAR (STD.DEV)	=	3.57
LIMITES DE CONFIANZA 95% (CONF.LIMITS ,95%)	=	±7.01
COEF. DE VARIACION % (COEFF. VARIANCE %)	=	9.45
ASIMETRIA (SKEWNESS)	=	-1.10

INTERVALO			HISTOGRAMA
24.50	-	26.99	*
27.00	-	29.49	
29.50	-	31.99	**
32.00	-	34.49	****
34.50	-	36.99	**********
37.00	-	39.49	**********
39.50	-	41.99	**********
42.00	-	44.50	*******

DATOS EN ORDEN ASCENDENTE
(DATA IN ASCENDING ORDER)

24.5	39
30	39.4
30	39.5
33	39.8
34	40
34	40
34	40
34.6	40
35	40
35.1	40
35.7	40.5
36	40.5
36	41.2
36	41.8
36	42
36.1	42
36.4	42
36.8	42
36.9	43.2
37	43.5
37	44.5
37.4	58 R2
37.8	60 R2
38	60 R2
38	78 R1
38	
38	
38	
38	
38.5	
38.5	
38.8	
39	

R1=DATO RECHAZADO, 4 DESV.ESTAND.
(REJECTED DATA, 4 STD.DEV)
R2=DATO RECHAZADO, PRUEBA T
(REJECTED DATA, t-test)

PARAMETRO (PARAMETER)	=	CLORURO I (CHLORIDE I)
N, DATOS TOTALES (N, ALL DATA)	=	59
NUMERO DATOS RECHAZADOS (NUMBER OF DATA REJECTED)	=	4
VALOR VERDADERO (TRUE VALUE)	=	28.10
PROMEDIO (MEAN)	=	29.97
MEDIANA (MEDIAN)	=	30.50
ERROR REL. % (PCT REL ERROR)	=	6.67
AMPLITUD (RANGE)	=	28.50
VARIANZA (VARIANCE)	=	27.79
DESV. ESTANDAR (STD.DEV)	=	5.27
LIMITES DE CONFIANZA 95% (CONF.LIMITS ,95%)	=	±10.33
COEF. DE VARIACION % (COEFF. VARIANCE %)	=	17.58
ASIMETRIA (SKEWNESS)	=	-0.99

INTERVALO			HISTOGRAMA
12.00	-	15.55	*
15.56	-	19.11	**
19.12	-	22.67	**
22.68	-	26.24	***
26.25	-	29.80	**********
29.81	-	33.36	**************************
33.37	-	36.92	******
36.93	-	40.50	****

DATOS EN ORDEN ASCENDENTE
(DATA IN ASCENDING ORDER)

8.9 R2	30.8
10.1 R2	30.9
12	31
16	31
19.1	31
20.8	31.1
21	31.5
23	31.8
23.5	32
26.2	32
26.6	32
28	32.3
28	33
28	33
28.4	33.9
28.5	34
29	34.4
29	35
29	35.3
29	35.6
29.6	38
30	40
30	40
30	40.5
30	53 R2
30.1	68 R1
30.2	
30.4	
30.5	
30.5	
30.7	
30.7	
30.8	

R1=DATO RECHAZADO, 4 DESV.ESTAND.
(REJECTED DATA, 4 STD.DEV)
R2=DATO RECHAZADO, PRUERA T
(REJECTED DATA, t-test)

PARAMETRO (PARAMETER)	=	CLORURO II (CHLORIDE II)
N, DATOS TOTALES (N, ALL DATA)	=	59
NUMERO DATOS RECHAZADOS (NUMBER OF DATA REJECTED)	=	3
VALOR VERDADERO (TRUE VALUE)	=	86.40
PROMEDIO (MEAN)	=	87.18
MEDIANA (MEDIAN)	=	90.00
ERROR REL. % (PCT REL ERROR)	=	0.90
AMPLITUD (RANGE)	=	69.00
VARIANZA (VARIANCE)	=	130.29
DESV. ESTANDAR (STD.DEV)	=	11.41
LIMITES DE CONFIANZA 95% (CONF.LIMITS ,95%)	=	±22.37
COEF. DE VARIACION % (COEFF. VARIANCE %)	=	13.09
ASIMETRIA (SKEWNESS)	=	-1.00

INTERVALO			HISTOGRAMA
48.00	-	56.61	**
56.62	-	65.24	
65.25	-	73.86	*******
73.87	-	82.49	***
82.50	-	91.11	**********
91.12	-	99.74	**********
99.75	-	108.36	****
108.37	-	117.00	*

DATOS EN ORDEN ASCENDENTE
(DATA IN ASCENDING ORDER)

12.1 R2	90.5
22.2 R2	90.5
48	91
56.5	91
66.5	91.5
70.9	91.5
72	91.5
72	92
72.3	92.1
72.4	93
73.7	93
74	93.5
74.5	93.6
81.5	94
83	94
83.5	94.9
85	95.4
85	96
86	96
86.9	98
87	100
87	100
87.6	102
87.9	102
88	117
88.9	196 R1
89	
89	
89.5	
90	
90	
90.3	
90.4	

R1=DATO RECHAZADO, 4 DESV.ESTAND.
(REJECTED DATA, 4 STD.DEV)
R2=DATO RECHAZADO, PRUEBA T
(REJECTED DATA, t-test)

PARAMETRO (PARAMETER)	=	FLUORURO I (FLUORIDE I)
N, DATOS TOTALES (N, ALL DATA)	=	43
NUMERO DATOS RECHAZADOS (NUMBER OF DATA REJECTED)	=	3
VALOR VERDADERO (TRUE VALUE)	=	0.20
PROMEDIO (MEAN)	=	0.22
MEDIANA (MEDIAN)	=	0.20
ERROR REL. % (PCT REL ERROR)	=	10.37
AMPLITUD (RANGE)	=	0.45
VARIANZA (VARIANCE)	=	0.00
DESV. ESTANDAR (STD.DEV)	=	0.08
LIMITES DE CONFIANZA 95% (CONF.LIMITS ,95%)	=	±0.16
COEF. DE VARIACION % (COEFF. VARIANCE %)	=	38.75
ASIMETRIA (SKEWNESS)	=	0.34

INTERVALO			HISTOGRAMA
0.00	-	0.04	*
0.05	-	0.10	**
0.11	-	0.15	******
0.16	-	0.21	**********
0.22	-	0.27	*******
0.28	-	0.32	****
0.33	-	0.38	**
0.39	-	0.45	**

DATOS EN ORDEN ASCENDENTE
(DATA IN ASCENDING ORDER)

0	.3
.1	.32
.1	.33
.12	.34
.12	.36
.15	.4
.15	.45
.16	.6 R2
.16	.6 R2
.17	.97 R1
.2	
.2	
.2	
.2	
.2	
.2	
.2	
.2	
.2	
.2	
.2	
.2	
.2	
.22	
.25	
.25	
.25	
.25	
.25	
.25	
.28	
.3	

R1=DATO RECHAZADO, 4 DESV.ESTAND.
(REJECTED DATA, 4 STD.DEV)
R2=DATO RECHAZADO, PRUEBA T
(REJECTED DATA, t-test)

PARAMETRO (PARAMETER)	=	FLUORURO II (FLUORIDE II)
N, DATOS TOTALES (N, ALL DATA)	=	43
NUMERO DATOS RECHAZADOS (NUMBER OF DATA REJECTED)	=	2
VALOR VERDADERO (TRUE VALUE)	=	1.10
PROMEDIO (MEAN)	=	1.18
MEDIANA (MEDIAN)	=	1.20
ERROR REL. % (PCT REL ERROR)	=	7.42
AMPLITUD (RANGE)	=	1.10
VARIANZA (VARIANCE)	=	0.03
DESV. ESTANDAR (STD.DEV)	=	0.18
LIMITES DE CONFIANZA 95% (CONF.LIMITS ,95%)	=	±0.37
COEF. DE VARIACION % (COEFF. VARIANCE %)	=	16.03
ASIMETRIA (SKEWNESS)	=	-0.59

INTERVALO			HISTOGRAMA
0.60	-	0.72	**
0.73	-	0.86	
0.87	-	1.00	******
1.01	-	1.14	*******
1.15	-	1.27	**********
1.28	-	1.41	**********
1.42	-	1.55	
1.56	-	1.70	*

DATOS EN ORDEN ASCENDENTE
(DATA IN ASCENDING ORDER)

.19 R2	1.3
.6	1.3
.7	1.32
1	1.32
1	1.36
1	1.4
1	1.4
1	1.42
1	1.7
1.02	2.75 R1
1.08	
1.1	
1.1	
1.1	
1.1	
1.14	
1.16	
1.2	
1.2	
1.2	
1.2	
1.2	
1.2	
1.2	
1.2	
1.23	
1.25	
1.25	
1.3	
1.3	
1.3	
1.3	
1.3	

R1=DATO RECHAZADO, 4 DESV.ESTAND.
(REJECTED DATA, 4 STD.DEV)
R2=DATO RECHAZADO, PRUEBA T
(REJECTED DATA, t-test)

PARAMETRO (PARAMETER)	=	SULFATO I (SULFATE I)
N, DATOS TOTALES (N, ALL DATA)	=	57
NUMERO DATOS RECHAZADOS (NUMBER OF DATA REJECTED)	=	0
VALOR VERDADERO (TRUE VALUE)	=	12.00
PROMEDIO (MEAN)	=	10.86
MEDIANA (MEDIAN)	=	11.00
ERROR REL. % (PCT REL ERROR)	=	-9.47
AMPLITUD (RANGE)	=	19.20
VARIANZA (VARIANCE)	=	17.58
DESV. ESTANDAR (STD.DEV)	=	4.19
LIMITES DE CONFIANZA 95% (CONF.LIMITS ,95%)	=	±8.22
COEF. DE VARIACION % (COEFF. VARIANCE %)	=	38.60
ASIMETRIA (SKEWNESS)	=	-0.15

INTERVALO			HISTOGRAMA
1.40	-	3.79	****
3.80	-	6.19	****
6.20	-	8.59	******
8.60	-	10.99	**********
11.00	-	13.39	**********
13.40	-	15.79	*******
15.80	-	18.19	*****
18.20	-	20.60	**

DATOS EN ORDEN ASCENDENTE
(DATA IN ASCENDING ORDER)

1.4	11.5
1.7	11.9
2.9	12
3.1	12
4.9	12
5	12
5.8	12.2
6	12.5
6.3	12.9
7	13.2
7	14
7	14.4
7	14.5
7.6	15
9	15.1
9	15.4
9.6	15.5
10	16
10	16
10	16.2
10	17
10.1	17
10.5	19.8
10.7	20.6
10.7	
10.8	
11	
11	
11	
11	
11	
11	
11.4	

R1=DATO RECHAZADO, 4 DESV.ESTAND.
(REJECTED DATA, 4 STD.DEV)
R2=DATO RECHAZADO, PRUEBA T
(REJECTED DATA, t-test)

PARAMETRO (PARAMETER)	=	SULFATO II (SULFATE II)
N, DATOS TOTALES (N, ALL DATA)	=	57
NUMERO DATOS RECHAZADOS (NUMBER OF DATA REJECTED)	=	2
VALOR VERDADERO (TRUE VALUE)	=	102.40
PROMEDIO (MEAN)	=	92.27
MEDIANA (MEDIAN)	=	98.00
ERROR REL. % (PCT REL ERROR)	=	-9.88
AMPLITUD (RANGE)	=	82.00
VARIANZA (VARIANCE)	=	371.55
DESV. ESTANDAR (STD.DEV)	=	19.27
LIMITES DE CONFIANZA 95% (CONF.LIMITS ,95%)	=	±37.78
COEF. DE VARIACION % (COEFF. VARIANCE %)	=	20.88
ASIMETRIA (SKEWNESS)	=	-1.42

INTERVALO			HISTOGRAMA
38.00	-	48.24	***
48.25	-	58.49	***
58.50	-	68.74	*
68.75	-	78.99	**
79.00	-	89.24	****
89.25	-	99.49	**********
99.50	-	109.74	**********
109.75	-	120.00	******

DATOS EN ORDEN ASCENDENTE
(DATA IN ASCENDING ORDER)

7 R2	100
38	100
40	100
45.8	100
50	100.4
53.2	101
56.2	101.6
62	102.5
72	104
78	105
80	106
82.1	106.4
82.3	106.5
84	107
89.5	107.5
89.6	108
90	109.5
91	110
92	110.3
92.5	112.4
92.9	112.6
93.6	117
94.4	120
94.6	185.2 R2
96	
97.1	
97.3	
97.9	
98	
98	
99.5	
100	
100	

R1=DATO RECHAZADO, 4 DESV.ESTAND.
(REJECTED DATA, 4 STD.DEV)
R2=DATO RECHAZADO, PRUEBA T
(REJECTED DATA, t-test)

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