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Estimation of the willingness to pay to decontaminate the interior bay in the city of Puno Perú. Applying the contingent valuation method

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Abstract: This paper exposes the contamination problem of the interior bay of Lake Titicaca in the city of Puno. The objectives of the research were: (1) Determine the average willingness to pay (DAP) on the part of the citizens of Puno for an improvement in the quality of the water of the contaminated bay, Propose a solution to the problem, establishing how this willingness could be captured to pay and what percentage this is of the average monthly sewerage payment. Data from a survey with a referendum-type format was used and the contingent valuation method was applied to determine the willingness to pay (DAP) for a change in water quality through the expansion and improvement of the current wastewater treatment plant. (construction of new lagoons). An average DAP of S/. 8.20/family/month, this is higher than the average monthly payment for sewerage for domestic use, which is S/. 7.91/month and therefore the DAP is greater than 100% of the average monthly payment for sewerage, for which it is convenient to capture this DAP in a payment vehicle expressed in an increase in the water rate.

Keywords: willingness to pay, contamination, Bahía interior, Puno, contingent valuation.

I. INTRODUCTION

Since many investments do not generate the benefits that had been expected from them, cost recovery is important to the sustainability of these investments. The low willingness to pay (DAP) of the users has been identified, which explains the low levels of cost recovery. The DAP does not express the true economic value of water, creating a financial gap between the costs of providing the service and the DAP. Non-market methods such as contingent valuation have been widely applied worldwide, enabling their scientific and practical development (Rojas et al, 2001).

The contingent valuation method is known as the hypothetical question method, because interviewees are offered conditions that simulate a hypothetical market in which they are asked DAP for current or potential conditions, which are not recorded in a market (Perez, 2000).

Studies are required to generate sanitation projects (improvements in sewerage and construction of treatment plants). The polluted bay negatively affects the well-being of the inhabitants, it causes fetid odors, the shores are not suitable for recreation and the bad image mainly affects tourism.

Clean water bodies are essentially a public good, where their improvement brings benefits to the entire community. For clean water bodies, market equilibrium prices and quantities are not completely efficient from a social perspective, the main reason being the existence of externalities.

It is necessary to implement a decontamination policy for the bay. Therefore, mechanisms for the implementation of this policy are required. For this, an economic mechanism is fundamental, knowing what is the willingness to pay of the population for decontaminating the bay. The main objective in this case is the recovery of the ecosystem of the bay, determining the monetary value that people grant for decontaminating the bay. This provides us with knowledge of the hypothetical amount available to finance the implementation of management and control programs for polluting agents.

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The fundamental questions would be:

Do you accept the Puno bay decontamination project?
How much is the population of Puno willing to pay to decontaminate the bay?
Are you willing to pay a hypothetical price for an improvement in the water quality of the bay?
The objectives of the research were: (1) Determine the average willingness to pay on the part of the citizens of Puno, for an improvement in the water quality of the contaminated bay, (2) Propose a solution to the problem, establishing how it could be Capture this willingness to pay and what percentage this is of the average monthly sewerage payment.

II. THEORETICAL FRAMEWORK

A. VALUE IN USE

Bouwes and Schneider (1979) cited by Just, Hueth and Schmitz (1982), justified preserving good levels of water quality in Pike Lake in Wisconsin USA, based on a site-specific contingent valuation (CVM) method. They assumed weak complementarity to estimate the changes in lake valuation between the ordinary aggregate demand curves, conditioned on good and low water quality indices. The estimated median value was US$38,964 per year, they used 195 observations, relating the objective measures of water quality; turbidity, dissolved oxygen, etc., with the subjective classification of recreationists regarding their perceptions and preferences for water quality. This last procedure still creates doubts in the demand functions, implying that the valuation measures are not reliable.

A variant of the contingent method called referendum was introduced by Bishop and Heberlein (1979) (cited by Freeman (1993)), which combines answers of the YES/NOT type, to analyze the willingness to pay (DAP) and the willingness to accept (DAA) for goose hunting permits in eastern Wisconsin, in a framework of simulated (real) markets and hypothetical markets. His simple logit model for estimating the value of hunting permits was not strictly compatible with utility theory. Hanemann (1984) and in his reply, determined the maximum DAP in a context of consumer utility maximization. Based on the responses obtained from the referendum technique (discrete dependent variable), he compared two indirect utility functions generating incremental utility, which is analogous to the integrability condition in conventional demand theory.

Ducci (1988), developed a methodology for quantifying benefits using the contingent valuation method, basing his theoretical scheme on Hanemann (1984), to estimate benefits of environmental sanitation of beaches in Montevideo Uruguay, the construction project of the western interceptor had The objective is to eliminate fecal contamination that affects the western area of Punta Carreta, including mainly Ramirez beach, on a sample of 1,500 families, obtaining a median (and median) willingness to pay (DAP) of about US $193, per family a year, to offer them a clean beach. On the other hand, it establishes the validity of some of the main hypotheses regarding the determinants of the benefits, thereby ensuring the consistency of the results obtained with the application of contingent valuation to this project.

Ardila (1993) developed a theoretical guide for the use of econometric models in the application of the contingent valuation method, taking into account its theoretical basis in Hanemann (1984). Develops a series of examples of estimation of models, welfare measures and confidence limits, using the information from the surveys carried out in the city of Porto Alegre Brazil to determine the benefits of a series of sewage treatment plants, which would improve the quality of the waters of the city's beaches.

B. WELFARE MEASURES

Welfare economics provides monetary measures of the change in people's well-being associated with changes in price levels or changes in quantities consumed. In general, two measures are defined called compensating variance (C) and equivalent variance (VE).

C. COMPENSATORY VARIATION (C)

It takes as a reference the level of utility that the consumer reaches in the situation without the project (U0) for the case of a reduction in the price level is equal to the amount of money that must be subtracted from the original income of the individual to make his The profit level with the project equals the profit level without the project.

D. EQUIVALENT VARIATION (VE)

It takes as a reference the level of utility that the individual would reach with the price change, being equivalent to the amount of money that would have to be given to the individual in the situation without the project, so that he reaches a level of utility similar to the one he would reach in the situation with project with the original income level.

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E. MATHEMATICAL DEFINITION OF C and VE

For a reduction in prices, C can be defined as the value such that

$$U(P_1, Y - C) = U(P_0, Y)$$

And VE is defined as

$$U(P_1, Y) = U(P_0, Y + VE)$$

Where 1 and 0 indicate situations with and without a project.

F. DETERMINATION OF THE COMPENSATED VARIATION

To find the compensated variation that takes the value of (C), which is the answer to the willingness to pay (DAP) question, in a linear model Vi.

The Vi model is

$$V(j, Y; S) = \alpha_j + \beta_j Y + \varepsilon_j; \qquad \beta > 0,$$

Where: j = 1 (with project) or j=0 (without project), V = indirect utility function, Y = income level, αj and βj = parameters, εj = error term εj ~N(0,σ2)

Then C for individual i can be defined as

$$U(1, Y - C; S) = U(0, Y; S)$$
$$V(1, Y - C; S) - V(0, Y; S) = \varepsilon_1 - \varepsilon_0$$

Where Vi is the indirect utility, Y income level, S socioeconomic factors, ε1 and ε0 are the errors, simplifying or omitting S momentarily, the incremental utility function (ΔV) would be expressed as:

$$\Delta V = \alpha + \beta C + \eta$$

Where

$$\alpha = \alpha_1 - \alpha_0$$
$$\eta = \varepsilon_1 - \varepsilon_0$$

If the errors are distributed as in a Probit model, the compensated variance is:

$$C^+ = DAP = \frac{\frac{\alpha}{\sigma}}{\frac{\beta}{\sigma}}$$

If the errors are distributed with a Logit model, the compensated variation is:

$$C^+ = DAP = \frac{\alpha}{\beta}$$

Which comes to be the first measure of well-being, that is, the mean (C+) of the distribution. The magnitude of the differences in the welfare measures for both the Probit and Logit models are irrelevant. For this reason, the Logit model is preferred because it admits greater variance in the distribution of the error term.

The Probit and Logit models are those that relate binary dependent variables (1 or 0). In a Probit model η follows a normal distribution with mean μ and variance σ2, its CDF is expressed as:

$$F(\eta) = \int_{-\infty}^{\eta} \frac{1}{\sqrt{2\pi}\sigma} e^{-\frac{1}{2}\left(\frac{\eta - \mu_\eta}{\sigma}\right)^2} d\eta$$

In a Logit model the errors are Logistically distributed, being the Logistic function;

$$P(\eta) = \frac{1}{1 + e^{-\eta}}$$

In a linear utility model such as Vi, the mean (C+) and median (C*) are equal. If no negative values for C are allowed, then the monetary measure of the welfare change across the mean (C+) is given by:

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$$C^0 = C^+ = \int_0^\infty \left(1 - G_C(P)\right) dP = \frac{\log(1+e^\alpha)}{\beta}$$

Where, GC(P) gives the probability that C is less than or equal to P, which is the probability of getting a negative answer, and 1 – GC(P) gives the probability that C is greater than P.

If the procedure is generalized and the vector S is included, the welfare measure is given by:

$$C^+ = C^* = DAP = \frac{\alpha' S}{\beta} = \frac{\sum_{i=0}^{k} \alpha_i S_{i+1}}{\beta}$$

Where, Si+1: set of socioeconomic characteristics, which includes income.

α': It is the transpose of the vector of parameters, and β is the coefficient of the price P (marginal utility of income).
Using a logarithmic functional form

$$V_i(j, Y; S) = \alpha_j + \beta \ln(Y) \qquad para, \beta > 0$$

Applying the increment for the situation with and without the project, the incremental function is expressed as

$$\Delta V = \alpha_1 - \alpha_0 - \frac{\beta C}{Y}$$

The ways of calculating the measures of welfare changes (C* and C') can be estimated from the following ways, shown in Table 1.

TABLE I FORMULAS FOR ESTIMATING THE MEAN AND MEDIAN MEASUREMENTS

Models	Mean (C')	Median (C*)
Logarithmic	$C' = e^{\frac{\alpha}{\beta}} \pi/\beta \sin(\pi/\beta)$	$C^* = e^{\alpha/\beta}$
Linear	$C' = \frac{\log(1+e^\alpha)}{\beta}$	$C^* = e^{\alpha/\beta}$

Methods have been developed for the estimation of the parameters of the above formulas.

G. CONTINGENT VALUATION METHOD (VC)

Currently, the contingent valuation method is the most widely used in the evaluation of projects for public goods and services and environmental projects in the USA and in other countries, with notable theoretical advances associated with its application in the empirical techniques used.

Contingent valuation is considered a form of direct estimation, since a sample of the population is asked directly how much they value a certain good for which there is no market. The application of the method is faced with the task of identifying the type of welfare measure that is intended to be estimated. The two most common are compensated variance and equivalent variance.

Through the variant of the contingent valuation method called the referendum technique, the DAP is deduced, which determines the use value of the resource.

The referendum technique refers to posing the question about willingness to pay not in an open, but binary way. Would you pay so much for…? Yes or no?

Recent developments in the method include the joint use of hypothesized behavior information in a single model along with advances in questionnaire design. The basic idea is that observations of hypothesized behavior reveal some evidence of DAP that can be used in conjunction with contingent valuation questionnaires.
The fundamental assumption is that people behave in the same way in a relevant real market as in a hypothetical market.

Florez (1996) determined the DAP by applying the contingent valuation method (MVC) using a referendum-type survey, applying his survey in September 1996. To carry out his research. In his research, he calculated the economic benefits of decontaminating the Puno Bay on Lake Titicaca in Peru.

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Barton (1999), carried out identical studies of contingent valuation (VC) of the DAP of households due to improvements in the quality of surface and well water in coastal areas in the cities of Jacó and Puntarenas, estimated that the average DAP in Jacó varies between 3085-4789 colones per month and for Puntarenas it varies between 2347-6617 colones/month.

Pérez (2000), gives as an example that a question of the contingent valuation method (MVC) of water can be:

Suppose that the management of water from an aquifer is changed in such a way that during the year, the volume that you can extract increases by 100 m3. What would be the maximum amount that you are willing to pay for such an increase?

According to Pérez (2000), the main advantage of the contingent valuation method is that it can potentially measure the value of water within the framework of economic theory. It also measures future as well as current values. It is the only technique that measures non-use values. It has been used to study demand for domestic water supply and sanitation improvement of the resource in rural villages in developing countries. The main drawback is its biases, its need for in-depth knowledge of econometrics, and its costs and time to conduct the study.

Sánchez (2002), in his study applied to the Laguna de los Mártires, Isla de Margarita, estimated the maximum willingness to pay (MDAP) for improving the current levels of non-marketable services, such as the quality of the Lagoon environment, through of an environmental recovery project, concludes that the MDAP is Bs. 4 261.64 per person.

Rivas and Ramoni (2007), in their study applied to the Albarregas river (Mérida-Venezuela) estimated the willingness to pay and the amount to be paid by the inhabitants of Mérida for the sanitation of the Albarregas, by applying the contingent valuation technique. Their results suggest a wide receptivity of the population towards this project, with an average contribution equivalent to one fifth of the monthly bill for water service.

Alfranca (2020) carried out his study where he carried out the Water Valuation and the application of the Stated Preferences method: Contingent Valuation against Choice Experiments. He claims that the stated preference methods use questions to individuals to establish their preferences against hypothetical scenarios.

Saldana-Escorcia et al. (2022) applied the contingent valuation method for the evaluation of groundwater quality improvement. They affirm that economic valuation is a tool to estimate monetary values of services provided by ecosystems that are ultimately beneficial to human beings.

H. THE MODEL

Assuming that the interviewee has a utility function U(J,Y;S), which depends on the income Y, and on the improvement of the water quality (current state J=0 or final state J=1), having as parameters the vector of socioeconomic characteristics S of the individual.

Since the function U(J,Y;S) is unknown, then a stochastic model of the form is proposed:

$$U(J,Y;S) = V(J,Y;S) + \varepsilon_j$$

Where, ε(J) is the random variable, ε(J)~N(0,σ2), and V is the deterministic part (indirect utility function).

If the interviewee agrees to pay $P to enjoy the improvement in water quality, it must be true that

$$U(1,Y-P;S) > U(0,Y;S)$$
$$V(1,Y-P;S) + \varepsilon_1 > V(0,Y;S) + \varepsilon_0$$
$$V(1,Y-P;S) - V(0,Y;S) > \varepsilon_0 - \varepsilon_1$$

Where ε0 and ε1 are independent and identically distributed random variables. Simplifying the notation

$$\Delta V > \eta$$

Where

$$\Delta V = V(1,Y-P;S) - V(0,Y;S)$$
$$\eta = \varepsilon_0 - \varepsilon_1$$

At this level, the YES/NOT answer is a random variable. The probability of an affirmative answer (YES) is given by

$$P(YES) = P(\Delta V > \eta) = P(\eta < \Delta V) = F(\Delta V)$$

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Where F is the cumulative probability function of η.

$$F(\Delta V) = \int_{-\infty}^{\Delta V} f(\eta)\, d\eta$$

With f(η) the pdf of η.

F(ΔV) indicates the probability that η is less than or equal to ΔV.

I. FUNCTIONAL FORM OF Vi: LINEAR

$$V_i = \alpha_i + \beta Y$$

Linear in income, where i (0,1), and a probability distribution for η, is obtained

$$\Delta V = (\alpha_1 - \alpha_0) - \beta P = \alpha - \beta P$$

Where β>0, since the expected value of utility (V) increases with income, implying that the higher P is in the survey, the lower ΔV will be and, therefore, the lower the probability that an individual answers YES. In the same way, this model only allows estimating the difference α1 – α2 = α, representing the change in utility due to the improvement in water quality and β, represents the marginal utility of income (constant). It is then verified that the payment (P*) that would leave the respondent indifferent (ΔV = 0) is equal to the change in utility (α) divided by the marginal utility of income (β). That is to say,

$$P^* = \frac{\alpha}{\beta}$$

If ΔV is associated with a normal probability distribution for η, with zero mean and constant variance, that is, η~N(0,σ2), a Probit model is obtained, whose SI response probability is modeled as

$$P(SI) = P(\Delta V > \eta) = P(\alpha - \beta P > \eta)$$
$$P\left(\frac{\alpha - \beta P}{\sigma} > \frac{\eta}{\sigma}\right) = P\left(\frac{\eta}{\sigma} < \frac{\alpha - \beta P}{\sigma}\right)$$
$$\mu = \alpha - \beta P$$
$$P\left(\frac{\eta}{\sigma} < \frac{\mu}{\sigma}\right) = \int_{-\infty}^{\frac{\mu}{\sigma}} N(e)\, de$$

Where

$$e = \frac{\eta}{\sigma}$$

If ΔV is associated with a logistic probability distribution for η, a Logit model is obtained, whose YES response probability is modeled as:

$$P(YES) = P(\alpha - \beta P > \eta) = \frac{1}{(1 + e^{-\alpha + \beta P})}$$
$$P(\eta < \alpha - \beta P) = \frac{1}{(1 + e^{-\alpha + \beta P})}$$

J. DIAGNOSIS OF THE POLLUTION PROBLEM IN THE INTERIOR BAY OF PUNO

The urban area of the city of Puno will grow significantly in the next 25 years, compared to the growth made in previous decades. In the year 2025, a regular projection is foreseen with a population of approximately 185 thousand inhabitants; that is to say, almost 58 thousand inhabitants more than at present.

Population growth is the cause of increased demand for sewerage services and therefore increases the wastewater load that needs to be adequately treated.

MINCETUR (2005), describes the situation and the causes of the problems in the interior bay of Puno as follows:

- Lack of a Comprehensive Plan for the management and conservation of the Interior Bay of Puno.
- Problems derived from periodic flooding in the Interior Bay of Puno.
- Deficiency in the rainwater drainage system.
- Deficiencies in sewage treatment systems.
- Location of oxidation ponds.

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- Discharge of treated water directly into Lake Titicaca.
- Entry of 16 sewage collectors or emitters as well as garbage dumps.
- All these agents are the main nutrients for the propagation of lentils.

According to Méndez (2000), the values of the total nitrogen parameters in samples from the Interior Bay of Puno are between 1 and 5 mg/L and of the total phosphorus are in the range of 0.1 and 1.5 mg/L. The values of these parameters are higher in water samples found at 80% depth than samples at 20% depth.

According to preliminary results of the study by Méndez (2000) according to the levels of phosphorus and total nitrogen in the water samples of the Interior Bay of Puno, it is categorized as a Bay with eutrophication.

The treatment plant through stabilization ponds meets its objective for which it has been designed to remove the total coliforms present in wastewater, but its objective is not to remove nutrients such as phosphorus and nitrogen.
Méndez (2000), recommends carrying out a complementary treatment to the stabilization lagoon in order to remove the nutrients that cause eutrophication of the Interior Bay of Puno.

According to MINCETUR (2005), the Interior Bay of Puno receives a high discharge of pollutants during the rainy season, which according to JICA are the following: 4170 kg/day of BOD5, 1,126 kg/day of total nitrogen and 108.5 kg/day of total phosphorus. In the dry season, the pollutant load is reduced to approximately 40% of that calculated for the rainy season.

The main source of contamination is the discharge of wastewater from the El Espinar Treatment Plant, which contributes 3,024 kg/day of BOD5, 1,026 kg/day of nitrogen and 98.3 kg/day of total phosphorus, which is equivalent to approximately 92 % of the polluting load received by the interior bay of Puno; the remaining 8% comes from drainage channels.

MINCETUR (2005) also mentions that the problem of contamination of the Interior Bay of Puno is a consequence of the dumping of wastewater. This problem dates back to the 1960s and increased in the 1980s, with the growth of the Puno population. Sewerage and wastewater treatment services have not increased in the same proportion as population growth.

Currently in Puno, the coverage of wastewater treatment is 58%, and it is expected that by 2010, it will reach 75%; This means that in the future an increase in the concentration of contaminants and extension of the contaminated area must be expected in the Interior Bay of Puno, which is worrisome given the level of contamination currently existing.

K. CHARACTERISTICS OF SEWAGE WATERS

a) Quantity

The total untreated sewage discharges from the city of Puno is around 200 l/s. The population that has a sewerage connection contributes with an organic load of 1276 kg/day. Most of the downloads are of domestic origin (82%), to a lesser extent of commercial (17%) and industrial (1%) origin.

b) Quality

The water has high levels of organic loads (nutrients) and bacteriological (high number of coliforms above 103/100 ml).

L. SEWAGE TREATMENT INFRASTRUCTURE

a. Collection Network

Puno's sewerage system is basically made up of eleven sewerage service drainage sub-basins. The existing collection network has a length of 145.9 km, with diameters that vary from 8" to 14", the pipes are mostly made of simple concrete material.

b. home connections

According to GORE PUNO (2021) the sewerage coverage in 2019 was 86.59 (%).

c. Trunk Collectors and Emitter

The Sewerage System has three main collectors and one emitter, called the Main Emitter.

d. Pumping Chambers/Impulse Lines

The Puno Sewerage System has four pumping chambers with their respective drive lines that contribute to the Main Emitter, and finally to the Wastewater Treatment Plant called Espinar.

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e. Sewage treatment

Drainage from the city of Puno is conducted to a treatment plant made up of a system of stabilization ponds arranged in series (primary and secondary), the system is called El Espinar Drainage Treatment Plant.
The Plant has as preliminary treatment a barred chamber system, which does not have the necessary maintenance frequency.

Both stabilization ponds have an irregular shape, their main characteristics are:

Primary Lagoon

It has an area of 13.4 Ha., with an average depth of 1.5 m, which gives it a useful volume of 204,600 m3, and a retention period of 18.08 days. For a temperature of 12.3° C, the organic load at entry is 398.5 mg./l BOD5 and at exit 210.5 mg./l BOD5. On the other hand, it has also been determined that the concentration of coliforms in raw sewage upon entry is 1 x 107 NMP/100 ml. and at the output of 7.67 x 105 NMP/100 ml.

Secondary Lagoon

It has an area of 7.90 Ha. with an average depth of 1.5 m and a useful volume of 118,350 m3 and for the inflow of 168 lps, retention period is 12.40 days. For a temperature of 12.3° C, the organic load at the outlet is 145.5 mg./l BOD5. On the other hand, it has also been determined that the coliform concentration at the outlet is 7.82 x 104 CFU/100 ml.
According to EMSAPUNO (2005), it is necessary to specify that the EPS has been executing the Drinking Water and Sewerage Project of the city of Puno, in merit of Supreme Decree No. 114-2000-EF signed between the Republic of Peru and the Kreditanstalt Fur Wiederaufbau KfW which will improve the health infrastructure and thereby substantially improve the quality of the Service. This situation poses important challenges for the following years.

M. WATER RATE

a. fee structure

According to EMSAPUNO (2022) the current rate structure for the town of Puno was published through communication No. 027-2022 of EMSAPUNO S.A. The fixed monthly charge is S/. 2.56.

TABLE II CURRENT TARIFF STRUCTURE OF THE TOWN OF PUNO

Class	Category	Monthly consumption range (m3)	Rate (S/./m3)		Consumption allocation (m3/ month)
			Drinking water	Sewerage	
Residential	Social	0 a 10	1.4749	0.4597	16
		10 a más	2.0487	0.6392	
	Domestic	0 a 10	1.4749	0.4597	12.5
		10 a 20	1.5574	0.4860	
		20 a 25	3.1684	0.9876	
		25 a más	3.4711	1.0832	
Nonresidential	Commercial and others	0 a 30	2.4206	0.7545	30
		30 a más	5.1621	1.6098	
	Industrial	0 a 60	4.7115	1.4683	60
		60 a más	7.1033	2.2150	
	State	0 a 35	2.1534	0.6706	40 90 150
		35 a más	3.4711	1.0832	

Source: Communiqué No. 27-2022 of EMSAPUNO S.A., published in July 2022.
Preparation: Tariff Regulation Department

N. AVERAGE MONTHLY PAYMENT FOR DOMESTIC SEWER

To determine the average payment for the sewerage service, the rate was multiplied, which is S/. 1.0832/m3 (domestic category residential class for a consumption range of 25 m3 or more) (EMSAPUNO, 2022) for an average consumption value of the domestic category of 7.3 m3/month (calculated based on information from August 2018 to December 2021) (EMSAPUNO, 2022). The calculation is presented below.

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$$Average\ Monthly\ Sewer\ Payment = \left(\frac{\text{S/. }1.0832}{\text{m3}}\right)\left(7.3\frac{\text{m3}}{month}\right) = \text{S/.}\,7.90736/\text{month}$$

III. MATERIALS AND METHODS

A. DESCRIPTION OF THE STUDY AREA: LOCATION

The city of Puno is located in the Department and Province of the same name at an altitude of 3810 meters above sea level, the average temperature is 9°C and it has an annual rainfall of 718 mm. According to census data, in the year 2017, the total population of the district of Puno has reached 128,637 inhabitants (INEI, 2018). The demographic growth rate of the city is 2.59% and it is estimated that there are 4.14 inhabitants/home. The territorial extension of the province is 10,430 hectares and it has the main basic services of health, telephone, electricity, etc.

B. DATA

It is important to design well the survey with which the willingness to pay data will be obtained. This must describe in an understandable way the improvement in an understandable way the improvement of the good that you want to value for the good construction of the hypothetical market.

To avoid biases in the contingent valuation method, the interviewee must be familiarized with the project, clearly explaining the improvement that it will have on the quality of the water in the bay, for which reason photographs and drawings must be provided.

In the present work, the contingent valuation method was applied with a referendum-type format using survey data, to determine the use value of the decontamination of the Puno bay. The referendum format avoids the starting error.

C. INFORMATION COLLECTION

The survey format was carefully designed to minimize bias. Before carrying out this, the population was made aware of the contamination problem in the bay through television broadcasting, distribution of posters, twenty days before applying the survey. Previously, campaigns to clean the bay had been carried out with institutions and organizations.
This allowed obtaining real information about the willingness to pay for a change in water quality, consciously by people.

With a pilot survey of 30 observations, it was determined that the hypothetical prices offered are 1, 2, 3, 4, 5, 6, 7, 8, 10 and 15 soles for the DAP, for the referendum type format.

IV. RESULTS AND DISCUSSION

A. DETERMINATION OF SAMPLE SIZE

For a population of N = 12750 families, the sample size was determined with the sampling formula by proportions, assuming that the probability of a YES response is 0.5.

$$n_o = \frac{Z^2 \times p \times q}{d^2} = 384.16 \cong 384$$

Where: no = unadjusted sample size, Z = Z statistic for 95% confidence level, Z = 1.96, p = probability of occurrence YES.

$$q = 1 - p$$

d = allowable error, 5%. The adjusted sample size is

$$n = \frac{n_o}{1 + \frac{n_o}{N}} = 372.77 \cong 373$$

But 405 surveys were collected for purposes of greater control and consistency. The city was also divided into three zones: zone 1, zone 2 and zone 3 (low, medium and high) and each one into four parts, and the survey was taken using systematic sampling.

With the survey, in addition to other variables, those of use value were defined, for the estimation of parameters of the Logit model.

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Dependent variable: PROB = Probability of response to the proposed price (1 = YES, 0 = NOT) Dummy variable. Independent variables: PH = Hypothetical price proposed in soles S/, Y = Monthly family income in soles S/, SEX = Dummy variable (1 = male, 0 = female), the education variable was represented by three dummy variables: ED1 = (1 = those who have completed and incomplete higher education, 0 = the rest), ED2 = (1 = those who have completed and incomplete secondary education, 0 = the rest), NP = Number of people per family, ENF = Presence of disease due to the contamination of the bay, dummy variable (1 = YES, 0 = NOT).

B. DESCRIPTIVE ANALYSIS OF THE DATA

The non-dichotomous variables such as the proposed hypothetical price (PH), monthly family income (Y), both in soles, and the number of people per family (NP), present the following variability according to their frequency distribution function.

The calculation of descriptive statistics and graphs were performed using Minitab software.

TABLE III DESCRIPTIVE STATISTICS OF THE INDEPENDENT VARIABLES HYPOTHETICAL PRICE (PH), INCOME (Y) AND NUMBER OF PEOPLE (NP)

Variable	N	Mean	Median	TrMean	StDev	SE Mean	Minimum	Maximum	Q1	Q3
ph	405	6.119	6	5.912	3.980	0.198	1	15	3	8.0
Y	405	697.500	600	637.100	510.000	25.300	70	5000	400	802.5
NP	405	6.225	6	5.951	3.017	0.150	1	20	4	7.0

Where: Q1 = first quartile, Q3 = third quartile

According to table 3 above, the median hypothetical price is 6,119 soles, the median income is 697.5 soles, and the average number of people per family is 6. The hypothetical price ranges from 1 to 15 soles, the income from 70 to 5,000 soles per month and the number of people per family from 1 to 20. The hypothetical price has a coefficient of variation (CV) of 65%, the income has a CV of 73%, and the CV of the number of people per family is 48%. Therefore income has the greatest variability.

These characteristics can be detailed by observing the corresponding histograms of each variable, shown in the following figures 1, 2 and 3.

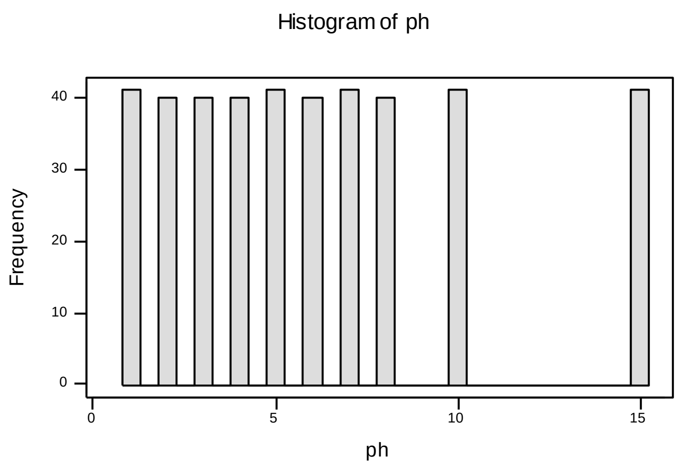

Fig. 1 Histogram of the hypothetical Price

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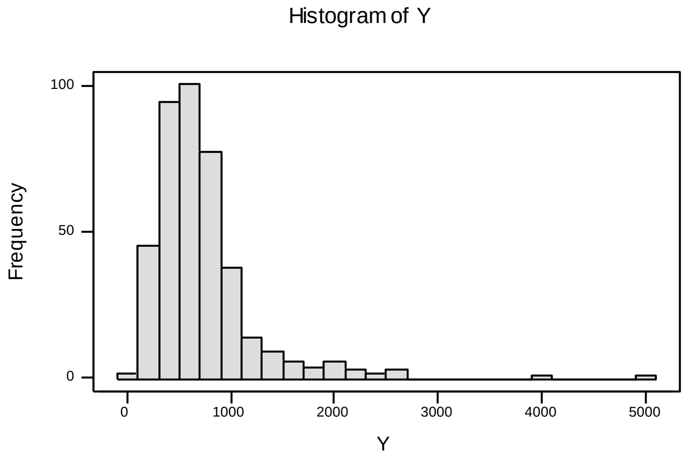

Fig. 2 Income histogram

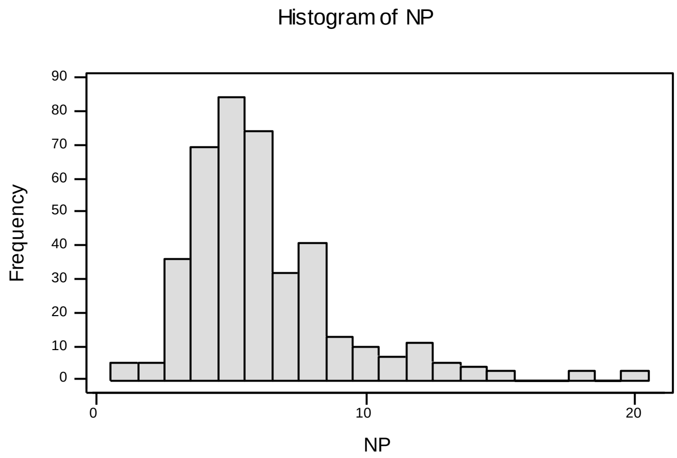

Fig. 3 Histogram of the number of people per family

C. ECONOMETRIC ESTIMATE

The Logit model, to estimate its parameters is as follows.

$$PROB = P(YES) = \frac{e^Z}{1+e^Z}$$

Or

$$PROB = P(YES) = \frac{1}{1+e^{-Z}}$$

Where for a linear model:

$$Z = \alpha + \beta_1 PH + \beta_2 Y + \beta_3 SEXO + \beta_4 ED1 + \beta_5 ED2 + \beta_6 NP + \beta_7 ENF$$

The estimate is made by applying the technique of maximizing the likelihood function.
For the case of a logarithmic model, it is done with

$$Z = \alpha + \beta_1 \ln(PH) + \beta_2 \ln(Y) + \beta_3 SEXO + \beta_4 ED1 + \beta_5 ED2 + \beta_6 NP + \beta_7 ENF$$

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In the estimation, the Eviews software was used, which is widely used in econometric estimation.

The estimation procedure is numerical, and the estimators that are obtained are those that maximize the likelihood function, for which a data sample of the survey results was used, the sample is 405 observations of the dependent and independent variables. Logit model parameters were estimated with linear and logarithmic Z. For the linear Z model, we have the results shown in the following table 4.

TABLE IV PARAMETER ESTIMATION RESULTS OF THE LINEAR LOGIT Z MODEL

Dependent Variable: PROB				
Method: ML - Binary Logit (Quadratic hill climbing)				
Sample (adjusted): 1 405				
Included observations: 405 after adjustments				
Convergence achieved after 6 iterations				
Covariance matrix computed using second derivatives				
Variable	**Coefficient**	**Std. Error**	**z-Statistic**	**Prob.**
C(1)	0.442559	0.472567	0.9365	0.349
PH	-0.209721	0.031292	-6.702113	0
Y	0.000467	0.000278	1.677632	0.0934
SEXO	-0.226485	0.1653	-1.370145	0.1706
ED1	1.156883	0.342712	3.375677	0.0007
ED2	1.127838	0.371043	3.039645	0.0024
NP	0.053365	0.041723	1.279041	0.2009
ENF	-0.385684	0.283174	-1.362006	0.1732
Mean dependent var	0.613861	S.D. dependent var		0.487467
S.E. of regression	0.441317	Akaike info criterion		1.166838
Sum squared resid	77.1254	Schwarz criterion		1.246074
Log likelihood	-227.7012	Hannan-Quinn criter.		1.198204
Avg. log likelihood	-0.563617			
Obs with Dep=0	156	Total obs		405
Obs with Dep=1	248			

In Table 4 above, it can be seen that the most significant independent variables are the hypothetical price, education levels, and income; therefore, these have a greater influence on a YES response to willingness to pay.

Likewise, the following table 5 presents the estimation results of the parameters of the Logit Z logarithmic model.

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TABLE V PARAMETER ESTIMATION RESULTS OF THE LOGARITHMIC LOGIT Z MODEL

Sample (adjusted): 1 405				
Included observations: 405 after adjustments				
Convergence achieved after 7 iterations				
Covariance matrix computed using second derivatives				
Variable	**Coefficient**	**Std. Error**	**z-Statistic**	**Prob.**
C(1)	-0.268746	1.288735	-0.208535	0.8348
LOG(PH)	-1.270164	0.185943	-6.830941	0
LOG(Y)	0.289493	0.201578	1.436137	0.151
SEXO	-0.235941	0.162953	-1.44791	0.1476
ED1	1.161967	0.358551	3.240727	0.0012
ED2	1.046681	0.378139	2.767979	0.0056
NP	0.051203	0.042172	1.21414	0.2247
ENF	-0.337315	0.283732	-1.188848	0.2345
Mean dependent var	0.613861	S.D. dependent var		0.487467
S.E. of regression	0.438459	Akaike info criterion		1.153536
Sum squared resid	76.12943	Schwarz criterion		1.232772
Log likelihood	-225.0143	Hannan-Quinn criter.		1.184902
Avg. log likelihood	-0.556966			
Obs with Dep=0	156	Total obs		405
Obs with Dep=1	248			

For this case, the most significant variables in the model are the natural logarithm of the hypothetical price, education levels, and gender. These variables are the ones that most influence the probability of answering YES to the willingness to pay question.

From tables 4 and 5, it can be said in general that the best model is the logarithmic model because it presents a lower Akaike information criterion, and also because it presents a higher log likelihood value than the linear model.

The linear model is the following

$$PROB = P(SI) = \frac{e^Z}{1 + e^Z}$$

Where Z for the linear model is

$$Z = 0.442559 - 0.209721PH + 0.000467Y - 0.226485\,SEXO + 1.156883ED1 + 1.127838ED2 + 0.053365NP - 0.385684ENF$$

and Z for the logarithmic model is

$$Z = -0.268746 - 1.270164 \ln PH + 0.289493 \ln Y - 0.235941SEXO + 1.161967ED1 + 1.046681ED2 + 0.051203NP - 0.337315ENF$$

The signs are as expected, if there is a higher hypothetical price there will be a lower probability of answering YES, if there is a higher income there will be a greater probability of answering YES, and if there is a greater number of people per family there will be a greater probability of answering YES to carrying out a project. decontamination of the bay as the extension of the current wastewater treatment plant.

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1.4. DETERMINATION OF VALUE IN USE: WILLINGNESS TO PAY AVERAGE DAP

The following table 6 shows the results of the survey and the estimates made with the linear and logarithmic Z models obtained in this work. Price is the hypothetical price, Freq (yes) is the number of people who answered YES, Cases is the number of people who are willing to pay the hypothetical price. It can be seen that 61% of people (249/405×100 = 61%) answered yes to the interest in the Puno bay decontamination project. Obs (%) is the observed probability of saying YES (for 1 g, 38/41×100 = 92.68 %), Est Lin (%) Est Logn (%) are the linear estimates of the probabilities of saying YES, and they were found applying the respective Logit models (linear and logarithmic Z).

TABLE VI RESULTS OF THE SURVEY, OBSERVED AND ESTIMATED PROBABILITY OF ANSWERING YES

Price S/.	Frec. (YES)	Cases	Obs (%)	Est lin (%)	Error Est Lin (%)	Est Logn (%)	Error Est Logn (%)
1	38	41	92.68	100.00	7.32	100.00	7.32
2	33	40	82.50	97.50	15.00	97.50	15.00
3	31	40	77.50	87.50	10.00	95.00	17.50
4	29	40	72.50	87.50	15.00	87.50	15.00
5	26	41	63.41	87.80	24.39	85.37	21.95
6	23	40	57.50	82.50	25.00	80.00	22.50
7	21	41	51.22	82.93	31.71	73.17	21.95
8	19	40	47.50	72.50	25.00	52.50	5.00
10	17	41	41.46	12.20	-29.27	12.20	-29.27
15	12	41	29.27	0.00	-29.27	0.00	-29.27
Total	249	405					
		DAP =	7.29	8.75		8.12	
SCE					5167.04		4018.02

The estimates of the probability of saying YES with respect to the observed one are shown in figure 4 below.

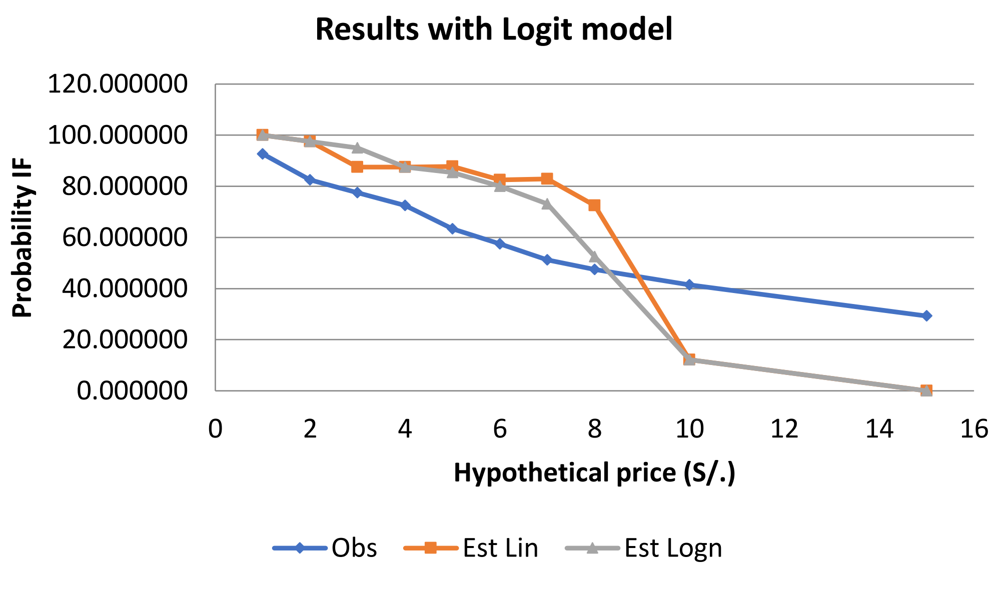

Fig. 4 Estimates of the probability of saying YES with respect to the observed

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There is the average willingness to pay as the price value that presents a probability of saying YES of 50%, for the observed values, values with linear and logarithmic estimation, we have

TABLE VII DETERMINATION OF MEAN DAP WITH OBSERVED VALUES

Observed values		**Linear estimation**		**Logarithmic estimate**	
Price S/.	**%**	**Price S/.**	**%**	**Price S/.**	**%**
7	51.2195	8	72.5	8	52.5
X	50	X	50	X	50
8	47.5	10	12.195122	10	12.195122

Interpolating for observed values x = DAP = S/. 7.289015286, Interpolating for linear estimation x = DAP = S/. 8.746208292, and interpolating for logarithmic estimation x = DAP = S/. 8.124054463 ≈ S/. 8.20

Table 6 shows the values of SCE (sum of squares of the error), the error is given as a percentage, and this SCE shows that the logarithmic Z model is more appropriate because it presents less SCE. Therefore, it is accepted that the average willingness to pay (DAP) of the population of Puno, for a decontamination project of the bay is S/. 8.20 per family per month.

The results obtained in this investigation are similar to those obtained by Saldaña-Escorcia et al. (2022) in terms of the influence of socioeconomic variables such as income, age, education and sex, also in that a direct and positive relationship was similarly obtained between DAP, education and income. Likewise, in the present investigation the contingent valuation method has been used, which is declared preferences as stated by Alfranca (2020), these methods are valid for estimating environmental values and therefore useful to solve environmental problems such as pollution of the water, allowing DAP to be determined for hypothetical scenarios of changes in environmental goods or services in the face of possible intervention projects to be carried out.

V. CONCLUSIONS

The average hypothetical price is 6,119 soles, the average income is 697.5 soles, and the number of people per average family is 6. The hypothetical price varies from 1 to 15 soles, the income from 70 to 5,000 soles per month, and the number of people per family from 1 to 20. The hypothetical price has a coefficient of variation (CV) of 65%, income has a CV of 73%, and the CV of the number of people per family is 48%. Therefore income has the greatest variability.
The most significant independent variables are the hypothetical price, education levels, and income; therefore, these have a greater influence on a YES response to willingness to pay. The most significant variables in the model are the natural logarithm of the hypothetical price, education levels, and gender. These variables are the ones that most influence the probability of answering YES to the willingness to pay question.

The best model is the logarithmic model because it presents a lower Akaike information criterion, and also because it presents a higher log likelihood value than the linear model.

The signs are as expected, if there is a higher hypothetical price there will be a lower probability of answering YES, if there is a higher income there will be a greater probability of answering YES, and if there is a greater number of people per family there will be a greater probability of answering YES to carrying out a project. Decontamination of the bay as the extension of the current wastewater treatment plant.

An average DAP of S/. 8.20/family/month, this is higher than the average monthly payment for sewerage for domestic use, which is S/. 7.91/month and therefore the DAP is greater than 100% of the average monthly payment for sewerage, for which it is convenient to capture this DAP in a payment vehicle expressed in an increase in the water rate.

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REFERENCES

[1]. Alfranca, Oscar. 2020. La Valoración del Agua y la aplicación del método de las Preferencias Declaradas: Valoración Contingente vs. Experimentos de Elección. Agua Y Territorio, NÚM. 15, pp. 101-114, Enero-Junio.

[2]. Ardila, S. 1993. Guía para la utilización de modelos econométricos en aplicaciones del método de valoración contingente. BID, Diciembre, 1 - 24.

[3]. Barton, D.N. 1999. The Quick, the Cheap and the Dirty. Benefit Transfer Approaches to the Non-Market Valuation of Coastal Water Quality in Costa Rica. Doctor Scientiarium Dissertation 1999:03, Department of Economics and Social Sciences, Agricultural University of Norway.

[4]. Bishop, Richard C. and Heberlein, Thomas A., (1979), Measuring Values of Extramarket Goods: Are Indirect Measures Biased?, American Journal of Agricultural Economics, 61, issue 5, p. 926-930.

[5]. Bouwes, N. W. and R. Schneider. 1979. Procedures in Estimating Benefits of Water Quality Change. American Journal of Agricultural Economics. Vol. 61.

[6]. Ducci, J. 1988. Metodología de cuantificación de beneficios en saneamiento. Universidad de los Andes. Santafé de Bogotá, Colombia.

[7]. EMSAPUNO. 2005. Plan financiero 2005 - 2009. EMSAPUNO. Puno. Perú.

[8]. EMSAPUNO. 2022. Proyecto De Estudio Tarifario. Aprobado en Sesión de Consejo Directivo 26 de agosto de 2022. Empresa Municipal De Saneamiento Básico De Puno Sociedad Anónima (EMSAPUNO S.A.) 2022 - 2027. Dirección de Regulación Tarifaria - DRT. SUNASS. Puno, Perú.

[9]. Florez, R. 1996. Cálculo de los beneficios económicos de descontaminar la bahía de Puno: Lago Titicaca Perú. Tesis de Magister en Economía del Medio Ambiente y Recursos Naturales. Universidad de los Andes. Santafé de Bogotá. Colombia.

[10]. Freeman, M. 1993. The measurements of environmental and resource values. Theory and methods. Resources for the future, Washington D. C.

[11]. GORE PUNO. 2021. Plan regional de saneamiento Puno 2021-2025. Gobierno regional Puno, Gerencia regional de desarrollo social, Dirección de vivienda y saneamiento. Puno, Perú.

[12]. Hanemann, W. 1984. Welfare evaluation in contingent valuation experiments with discrete responses. Amer. J. of Agr. Econ. 66 (1), 332 - 341.

[13]. INEI. 2018. Censos Nacionales XII de Población y VII de Vivienda, 22 de octubre del 2017, Perú: Resultados Definitivos. Octubre de 2018, Lima, Perú.

[14]. Just, R. Hueth, D. and Schimtz, a. 1982. Applied welfare economics and public policy. Englewood cliffs, Prentice Hall.

[15]. Méndez, L. C. 2000. Estudio de la calidad del agua de la bahía interior de Puno. Dpto de Física y Meteorología. UNALM. Lima. Perú.

[16]. MINCETUR. 2005. Acondicionamiento turístico del lago Titicaca. Proyecto Piloto "Malecón Eco-turístico". Ministerio de Comercio Exterior y Turismo. Lima. Perú.

[17]. Pérez, J. 2000. Valoración económica del agua. CIDIAT, Universidad de los Andes, Merida, Venezuela, 45 pp.

[18]. Rivas, A. y Ramoni, J. 2007. Valoración contingente aplicada al caso del río Albarregas Mérida Venezuela. Fermentum, Mérida, Venezuela 17(19): 478-502.

[19]. Rojas, J. Perez, M. y Peña, M. 2001. La valoración contingente: una alternativa para determinar la viabilidad de proyectos de tratamiento de aguas residuales en zonas rurales de países tropicales. Instituto Cinara. Universidad del Valle, Cali, Colombia.

[20]. Saldaña-Escorcia, R.; Jiménez-Lobo, D.; Guerrero-Durán, J. A. 2022. Método de valoración contingente para la evaluación del mejoramiento de la calidad del agua subterránea. Ciencia Transdisciplinar en la Nueva Era. Edgar Serna M. (ed.). Edición 1. Pags: 10-18.

[21]. Sánchez, J. 2002. Valoración económica del proceso de descontaminación en la Laguna de los Mártires, Isla de Margarita, Venezuela. Agroalimentaria, Mérida, Venezuela Enero (14): 89-103.