WEB TECHNOLOGIES USED TO FORECAST FUTURE WASTE QUANTITIES

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Abstract:
In this article the authors propose a modality of prognosis of the quantities of waste generated in a certain period. The proposition was finalized by achieving a model of prognosis present on a site hosted by a Web server. The software solve the problem for the general case, depending on the input data after analysis. After analyzing input data sets are used with one, two or three components (trend, seasonality and residual variable). According to the input data the adjustment model regarding the description of the analyzed phenomenon (additive and multiplying) is chosen. If the chronogram of the analyzed phenomenon indicates an oscillating evolution, of sinusoidal nature, the additive model (+) is chosen, otherwise the multiplying model (●) is chosen. The seasonal component is estimated and the deseasonalized chronological series is determined. The seasonality is determined by: the procedure of arithmetical means, the procedure of moving averages and the procedure of analytical tendency. The adjustment function is specified regarding the tendency of the phenomenon and its parameters are estimated. The significance of the adjustment function is verified specifying the significance threshold with which it may be accepted as significant. The estimation of the parameters of the adjustment function is made on the basis of the application of the method of least squares. The values of the phenomenon on two or three trimesters/ months are estimated for the processed data (by using time series with two or three steps ahead). Several types of waste specified by the value of the meter for waste from the database may be accepted. The model proposed makes decisions and justifies if the data prognosticated is accepted or not. All information from the input data to the final data is stored in a MySQL database.

Key words: web server, database, prognosis, time series, trend, seasonality, residual variable

JEL classification: A10, C13

1. REACHING THE OBJECTIVE REGARDING THE „ZERO WASTE" ENVIRONMENT DESIGN

The first objective of any country in the domain of waste management is the reduction to a minimum of the negative effects of generating and waste management on the health of the population and on the environment. The policy regarding waste aims at the reduction of the consume of resources and favours the practical application of the hierarchy of the waste, which classifies different options of waste management from the best, to the worst for the environment, like: prevention, re-use, recycling, energy recovery and elimination by incineration or storage. Although the hierarchy of waste does not have to be regarded as a rigid rule, the purpose of going to a recycling and recovery company means that re-using and recycling the materials should be preferred to the energy valorification and this to elimination by incineration or storage.
The Action for Environment Program, settles as priorities of the policy in the domain of environment protection, the use of natural resources and waste management. Thus, two strategies were lauched, namely:

- *Theme strategy regarding the durable use of natural resources*, which aims at reducing the negative impacts on the environment caused by the use of natural resources for the economic growth;
- *Theme strategy regarding the prevention and recycling of waste*, a long run strategy of any state which promotes a „recycling society", also supplying the background for the review of the waste policy; through this strategy is wanted the clarification and the simplification of the legislative frame , and the introduction of new instruments in the waste management, like the analysis of life cycle.

One of the measures taken for the protection of the environment at the level of any state is the review of the frame directive of waste.

The main objective of the directive is the prevention of generating waste and the reduction of the impact associated with it on the environment, and also the reduction of general effects of using resources and increasing the efficiency of using them. Other objectives of the frame directive of waste are:

- adding a mechanism that permits the clarification of the moment in which a waste ceases to be waste („end of waste");
- clarification of the definitions of certain operations of waste management;
- introduces the hierarchy of waste as an order of priorities for what represents the best option from the point of view of environment protection;
- inclusion of the provisions regarding the dangerous waste;
- clarification of the provisions regarding the plans of waste management and specification of the necessity of taking into consideration the entire life cycle of waste, at the moment of the development of plans;
- request that any state work out programs of prevention of waste production.

The problem of waste management manifests itself, stronger and stronger, because of the increase of the quantities and diversity of waste, as well as their negative impact, more and more visible, on the environment. The urbanistic and industrial development of the localities, as well as the general increase of the living standard of the population, trains the production of bigger and bigger quantities of waste. By the variety of organic and inorganic substances contained, they make that the process of aerobic and anaerobic degradation by the microorganisms be difficult to conduct, provoking, in case of evacuation and uncontrolled storage, the pollution of the ground, air and water. In the light of clean production (prevention of pollution) and eco-efficiency, "**zero waste**" represents a principle of eco-design (or the environment design) for the future. It includes recycling, which has in view the fluxes of resources and waste at the level of the society: maximizes recycling, minimizes waste, reduces the consumptions and assures that the products are made to be repaired, regenerated, recycled , re-used on the market and in nature. "**Zero waste**" makes from recycling a strong point of entering a cyclic loop of excessive consumption (the second component, besides production, of durable development). Moreover, "**zero waste**" does not have in view to treat in order to store or incinerate it. Treatment is accepted only in the sense of transforming the waste into a useful material for total use of its potential. In this sense modern systems of prognosis of the quantity of waste generated in a certain period of time. Among these we can recall: ARIMA and GARCH.

2. THE PRESENT STAGE REGARDING THE EVOLUTION OF SYSTEMS OF PROGNOSIS OF THE QUANTITIES OF PRODUCED WASTE .

The evolution of the systems of prognosis of the quantity of waste is illustrated by the tests and statistical models which were and are used at present.
The main techniques and models used are:

- moving average processes (MA(q))
- self -regressive processes (AR(p))
- mixed processes (ARMA(p,q))
- integrated series (ARIMA(p,n,q), ARFIMA(p,d,q))
- co-integrated series, processes ARCH, GARCH.

The chronological series represents a systematized set of values of a variable measured at moments or equal and successive time intervals. The chronological series is also named dynamic series or time series. From a mathematical point of view, the time series is an achievement of a stochastic process $\{X_t\}_t$ where $t \in \mathbf{Z}$ or to a set from **Z**, and the space of the states of the process (that is $\{X_t(\omega), \omega \in \Omega\}$) is the set **R** or one of its subsets.

The analysis of time series, the identification, evaluation and separation of the components offer information regarding:
i) the trend, that is the existence of a dominant evolutive sense, which manifests itself especially in conditions of normality of the carrying on of the process;
ii) the appearance of some systematic periodical fluctuations, with big chances to repeat in the future, as a sense and as an extent;
iii) the predictable aspect of the evolution of some processes, as a response to some deviations in the past;
iv) identifying the unessential factors, permitting their possible elimination;
v) the inertial character of carrying on some processes.

2.1. Time series models

2.1.1. The additive model of time series

The model is defined by the following relation:

$$Y = T + S + R$$

where : Y is the known value of the time series,
T is the trend component,
S is the seasonal component,
R is the residual component.

2.1.2. The multiplying model of time series

The model is defined by the following relation:

$$Y = T \cdot S \cdot R$$

where : Y, T, S, R have the above significance.

2.2 Models of ARMA, ARIMA, ARFIMA , ARCH type

2.2.1. ARMA(p,q) mixed processes

Are autoregressive processes $\{X_t\}$ of p order with moving average residuals of q order which verify the relation $X_t + \alpha_1 \cdot X_{t-1} + \cdots + \alpha_p \cdot X_{t-p} = Z_t + \beta_1 \cdot Z_{t-1} + \cdots + \beta_q \cdot Z_{t-q}$, where Z_t s are moving average residuals of q order.

2.2 .1. Non –stationary autoregressive processes and of *ARIMA*(*p,n,q*) moving average

Are non-stationary processes that in the original form present tendency and by n order differences may be brought to the stationary form, p being the order of the autoregressive part and q the order of the moving average part of the model.

For $ARIMA(1,1,2)$ the equation is : $\nabla y_t = \alpha_0 + \alpha_1 \cdot y_{t-1} + \overline{y} + Z_t + \beta_1 \cdot Z_{t-1} + \beta_2 \cdot Z_{t-2}$

2.2.2. The ARFIMA (Autoregressive Fractionally Integrated Movie Average) model

It is a variant of the $ARIMA(p,d,q)$ model in which d is the order of difference and is a fraction from 1 (0<d<1). Using the differentiation operator back (sending back in time) B, we have:

$(1-B)^d \cdot y_t = z_t$, $z_t \sim N(0, \sigma_z^2)$, $0 < d < 1$, where:

$$(1-B)^d = 1 - d \cdot B + \frac{d \cdot (d-1)}{2!} \cdot B^2 - \frac{d \cdot (d-1) \cdot (d-2)}{3!} \cdot B^3 + \cdots$$

Thus, the general form of *ARFIMA* is

$(1-B)^d \alpha(B) y_t = \beta(B) z_t$, where α, β, B have the significances

- $\alpha(B) y_t = z_t$
- (model $AR(p)$, that is $y_t = \alpha_0 + \alpha_1 \cdot y_{t-1} + \cdots + \alpha_p \cdot y_{t-p} + z_t$)

- $y_t = \beta(B) \cdot z_t$
- (model $MA(q)$, that is $y_t = \overline{y} + z_t + \beta_1 \cdot z_{t-1} + \cdots + \beta_q \cdot z_{t-q}$)

2.2.3. Integrated series

The integrated series is the non-stationary time series that by the differences of first or second order (that is $\nabla y_t = y_t - y_{t-1}$, $\nabla^2 y_t = \nabla y_t - \nabla y_{t-1}$) may be transformed into a stationary series.

2.2.4. Co-integrated series

Are the chronological series that being integrated by the same order admit a linear combination that is stationary (integrated of zero order) or is integrated of smaller order than the integration order of the initial series.

Example . The series $\{x_t\}, \{y_t\}$ have the same integration order and there is $\{z_t\}$, where $z_t = y_t - (a + b \cdot x_t)$ which is stationary.

2.2.5. ARCH (Autoregressive Conditional Heteroskedasticity)processes

By unequal dispersions (heteroskedasticity) of the residual values in time (that is a dependence in the form of autocorrelation also for residual variables) F.R. Engle proposed that the dispersion of error be dependent on the values y_{t-1} or z_{t-1}. Thus we have:
$\sigma_{z_t}^2 = \alpha_0 + \alpha_1 \cdot y_{t-1}^2$ or the variant $\sigma_{z_t}^2 = \alpha_0 + \alpha_1 \cdot z_{t-1}^2 + \cdots + \alpha_p \cdot z_{t-p}^2$.

Unlike the *AR* model in which z_t is considered random, normally distributed and with constant dispersion, and $E(y_t | y_{t-1}) = a \cdot y_{t-1}$ (the conditioned average is dependent on time), in Engle's version the error dispersion is dependent on time (from here the initials *CH* added to *AR*). A simple variant of the model is:
$y_t = a \cdot y_{t-1} + b \cdot x_t + z_t$, where $z_t \sim N(0, \sigma_{z_t}^2)$, $\sigma_{z_t}^2 = \alpha_0 + \alpha_1 \cdot z_{t-1}^2$

An important limitation of *ARMA* models is given by the fact that it treats too rigidly the conditioned variance of X_{t+k} . The class of *ARMA processes with conditional autoregressive heteroskedasticity* or *ARMA-ARCH processes permits to the conditioned variance of* X_t to depend on the history of the process. A time series with zero average, $\{X_t\}$, is a pure process *ARCH*(1) if $X_t = \sigma_t \cdot Y_t$, $\{Y_t\} \sim IID(0,1)$, (it is written $\{X_t\}$~*ARCH* (1)), where σ_t (stochastic volatility) is an element of stochastic process that verifies the relation $\sigma_t^2 = \omega^2 + \alpha \cdot X_{t-1}^2$ with $\omega \neq 0$ and $\alpha > 0$. Because $E(X_t^2 | S_{t-1}) = \sigma_t^2 = \omega^2 + \alpha \cdot X_{t-1}^2$, an *ARCH*(1) process for X_t corresponds to a *AR*(1) process for X_t^2. If $0 \le \alpha < 1$, then the *ARCH*(1) process is stationary and its unconditioned variance is $\overline{\sigma}^2 = \frac{\omega^2}{1-\alpha}$.
The difference between the conditioned and unconditioned variance is $\sigma_t^2 - \overline{\sigma}^2 = \alpha \cdot (X_{t-1}^2 - \overline{\sigma}^2)$.

We have
$E(X_{t+1}^2 | S_{t-1}) - \overline{\sigma}^2 = E(\alpha \cdot (X_t^2 - \overline{\sigma}^2) | S_{t-1}) = \alpha \cdot (\sigma_t^2 - \overline{\sigma}^2)$

Repeating this formula we obtain $E\left(X_{t+k}^2 \middle| S_{t-1}\right) - \overline{\sigma}^2 = \alpha^{k+1} \cdot \left(X_{t-1}^2 - \overline{\sigma}^2\right)$, $k = 1,2,\ldots$ Thus, $E\left(X_{t+k}^2 \middle| S_{t-1}\right) \xrightarrow[k\to\infty]{} \overline{\sigma}^2$.

A simple generalization of the pure $ARCH(1)$ process is the pure $ARCH(m)$ process, where $\sigma_t^2 = \omega^2 + \alpha_1 \cdot X_{t-1}^2 + \cdots + \alpha_m \cdot X_{t-m}^2$ with $\alpha_j \geq 0,\ j = \overline{1, m-1},$, and $\alpha_m > 0$, which corresponds to a $AR(m)$ process for X_t^2.

3. THE ECONOMETRIC ANALYSIS OF TIME SERIES. THEORETICAL CONCEPTS.

3.1. Econometric models with three components: trend, seasonality and residual variable

This type of models is applied when the series is built on annual subperiods (months, trimesters, semesters). Such a series is presented in the form of a table (see table 1).

Table 1. Presentation of the model with three components (trend, seasonality and residual variable)

Years I=1,2,...,n	Subperiods j = 1,2,...,m					Total	$\overline{y}_{i\cdot}$
	1	....	J	...	m		
1	y_{11}	....	Y_{1j}	...	y_{1m}	$\sum_{j=1}^{m} y_{1j}$	$\overline{y}_1$
.	.	....		...			
I	y_{i1}		y_{ij}		y_{im}	$\sum_{j=1}^{m} y_{ij}$	$\overline{y}_i$
.		....		...			
N	y_{n1}		y_{nj}		y_{im}	$\sum_{j=1}^{m} y_{nj}$	$\overline{y}_n$
Total	$\sum_{i=1}^{n} y_{i1}$	....	$\sum_{i=1}^{n} y_{ij}$	...	$\sum_{i=1}^{n} y_{im}$	$\sum_{i=1}^{n} \sum_{j=1}^{m} y_{ij}$	-
$\overline{y}_{\cdot j}$	$\overline{y}_{\cdot 1}$	....	$\overline{y}_{\cdot j}$	...	$\overline{y}_{\cdot m}$	-	$\overline{y}_0$

where:

- y_{ij} – represents the input values of the phenomenon registered in the subperiod j (j=1,2,...,m) of the year i (i=1,2,....,n).
  If t=j+m*(i-1), then the input data of the phenomenon is set in order in time after the variable y_t, t=1,2,.....,nxm.
  The values of the variables $\overline{y}_{\cdot j}$, $\overline{y}_{i\cdot}$ *si* $\overline{y}_0$ are calculated after the formulae:

$$\overline{y}_{\cdot j} = \frac{\sum_{i=1}^{n} y_{ij}}{n} \text{ - the average values of subperiod j} \quad (1)$$

$$\overline{y}_{i\cdot} = \frac{\sum_{j=1}^{m} y_{ij}}{m} \text{ - the annual average values of the series} \quad (2)$$

$$\overline{y}_0 = \frac{\sum_{i=1}^{n}\sum_{j=1}^{m} y_{ij}}{n \cdot m} = \frac{\sum_{i=1}^{n} \overline{y}_{i\cdot}}{n} = \frac{\sum_{j=1}^{m} \overline{y}_{\cdot j}}{m} \text{ - the general average of the series (3)}$$

- If the existence of the three components- trend, seasonality and random variable can be accepted, then the series can be modelled with a model in the form of:

$$\left.\begin{array}{l} y_t = f(t)+s(t)+u(t) \text{ or} \\ y_t = f(t)*s(t)*u(t) \end{array}\right\} \quad (4)$$

The structure of the model can be decided by using two methods:

4.1.the graphical method;

4.2. the variation analysis method.

3.2. The graphical method

Consists in building superposed curves, made on subperiods of time j.

If the graphical representation results in the form of superposed curves, ascending or descending, having a point of maximum or minimum, the hypothesis of a model with three components is retained: trend, seasonality and random variable, and if it is presented in the form of some curves that intersect, it implies the existence of a trend, the phenomenon being stationary.

3.2. The method of the variation analysis

It is based on the decomposing of the global variation of the phenomenon y_t on the three components: y_t variation provoked by essential factors (f(t)), by seasonal factors (s(t)) and residual factors (u(t)). The use of the method of variation analysis starts from the definition of these variations with the help of the following relation:

$\Delta_y^2 = \sum_i \sum_j (y_{ij} - \overline{y_0})^2$ - total variation of the phenomenon; (5)

$\Delta_{y/t}^2 = \sum_i \sum_j (\overline{y_i} - \overline{y_0})^2$ - the variation of y explained by the trend component, effect of the action of essential factors; (6)

$\Delta_{y/s}^2 = \sum_i \sum_j (\overline{y_j} - \overline{y_0})^2$ - the variation of y explained by the seasonal component, effect of the action of seasonal factors; (7)

$\Delta_{y/u}^2 = \sum_i \sum_j (y_{ij} - \overline{y_i} - \overline{y_j} + \overline{y_0})^2$ - the variation of y generated by the action of random factors (the residual component). (8)

Between these terms there is the relation:

$$\Delta_y^2 = \Delta_{y/t}^2 + \Delta_{y/s}^2 + \Delta_{y/u}^2 \quad (9)$$

Because the time series on the basis of which the econometric description of the character of the evolution of the phenomenon is wanted represents only a segment, only a part from its long - standing evolution, it can be assimilated to a poll and the verification of the indicators calculated on the period of time analyzed is imposed.

Testing the significance of the results obtained can be made with the ”F” – Fisher Snedecor test, knowing that

$$F_{cal}^1 = \frac{\Delta_{y/t}^2}{n-1} : \frac{\Delta_{y/u}^2}{(n-1)(m-1)} \qquad (n=10, m=12) \qquad (10)$$

$$F_{cal}^2 = \frac{\Delta_{y/s}^2}{m-1} : \frac{\Delta_{y/u}^2}{(n-1)(m-1)} \qquad (11)$$

From the table of Fisher – Snedecor distribution is taken the theoretical value corresponding to the two calculated values, $F_{cal}^{1}\quad si\quad F_{cal}^{2}$.

Choosing a significance threshold α = 0.05 or α = 0.01, from the table of Fisher – Snedecor distribution the theoretical values corresponding to the two calculated values are taken .

If $F_{cal} > F_{tab}$, then the significance of the respective components is accepted, that is the specification of the adjustment model is made with the help of the relations (4).

4. THE STRUCTURE OF THE FORECAST MODEL OF THE QUANTITIES OF WASTE IN TIME

Generally, in case of a model structured on three components, the statistic calculuses are made in the following order:

a) estimation of the seasonal component and the calculus of the corrected series of seasonal variations (S.C.V.S);
b) estimation of the trend component on the basis of the deseasonalized series and the rezidual component.
c) verification of the correctness of the model;
d) the use of the model (if it is accepted) at the explanation, simulation and prognosis of the analyzed phenomenon.

The seasonal component can be expressed, either in relative form- the seasonality coefficients , $k_{j,}$ or in an absolute form, $s_{j.}$

As a rule, the seasonal component is calculated ratio trend component.

According to the modalities of expression of the tendency, the seasonality can be determined through more preocedures, among which:

a) The procedure of arithmetical means;
b) The procedure of average at intervals
c) The procedure of cyclical averages;
d) The procedure of moving average;
e) The procedure of analytical tendency.

In practice the procedures a), d) şi e). are used.

4.1. The procedure of arithmetical means

Consists in comparing the values y_{ij} with the annual mean $\overline{y_i}$ and calculating the arithmetical means of these values, on the superperiods of the years.

Thus:

- the seasonality in absolute value s_j results from the realtion:

$$s_j = \frac{\sum_{i=1}^{n}(y_{ij} - \overline{y_i})}{n} = \frac{\sum_{i=1}^{n} y_{ij}}{n} - \frac{\sum_{i=1}^{n} \overline{y_i}}{n} = \overline{y_j} - \overline{y_0}$$

$\sum_{j=1}^{m} s_j = \sum_{j=1}^{m} \overline{y_j} - m \bullet \overline{y_0} = m \bullet \overline{y_0} - m \bullet \overline{y_0} = 0,$ respecting the criteria of the equivalence of the series $\sum y_t = \sum f(t),$ and the condition $\sum u_t = 0.$

- the seasonality in relative value $k_{j,}$ respectively the seasonality coefficients are calculated as simple arithmetical means, on the subperiods j, from the ratios of the empirical values y_{ij} as compared to the annual means $\overline{y_j}$:

$$k_j = \frac{\sum_{i=1}^{n} \frac{y_{ij}}{\overline{\overline{y}}_i}}{n} = \frac{1}{n} \cdot \sum_{i=1}^{n} \frac{y_{ij}}{\overline{\overline{y}}_i};$$

$$\sum_{j=1}^{n} k_j = \frac{1}{n} \cdot \sum_{i=1}^{n} \sum_{j=1}^{m} \frac{y_{ij}}{\overline{\overline{y}}_i} = \frac{1}{n} \cdot \sum_{i=1}^{n} \frac{1}{\overline{\overline{y}}_i} \cdot \sum_{j=1}^{m} y_{ij} = \frac{1}{n} \cdot \sum_{i=1}^{n} \frac{1}{\frac{\sum_{j=1}^{m} y_{ij}}{m}} \cdot \sum_{j=1}^{m} y_{ij} = \frac{m}{n} \cdot n = m$$

So, in case of the multiplying model – $y_t = f(t) x\ k_t + u_t$, for which:

$$\sum u_t = 0 \Rightarrow \sum y_t = \sum f(t)$$

$$\sum f(t) = \sum f(t) \cdot k_t \Rightarrow \sum f(t)(k_t - 1) = 0$$

there is the condition that:

$$\sum_{j=1}^{m} k_j - 1 = 0 \Rightarrow \sum_{j=1}^{m} k_j = m$$

If as a result of the calculuses, because of the rounding off of the figures, the two conditions are not verified, these are corrected.

$$\sum_{j=1}^{m} s_j = a \neq 0, \quad s_j^* = s_j - \frac{a}{m} \Rightarrow \sum_{j=1}^{m} s_j^* = 0$$

$$\sum_{j=1}^{m} k_j = a \neq m \quad k_j^* = k_j \cdot \frac{m}{a} \Rightarrow \sum_{j=1}^{m} k_j^* = m$$

Generally, in practice, the seasonality is expressed through the seasonality coefficients k_j, calculated on the basis of the annual arithmetical means $\overline{y_i}$: $k_{ij} = \frac{y_{ij}}{\overline{\overline{y}}_i}$; $k_j = \frac{1}{n} \cdot \sum k_{ij}$.

If $k_j > 1$, it results that a strong seasonality is manifested in subperiod j.

This procedure of expressing the seasonality is not used but in order to emphasize the intensity of the seasonality because of the restrictive hypothesis on which is based.

- constant tendency on the year subperiods.

$$f(t) = f[j + m(i-1)] = \overline{y}_j, \quad \forall j = \overline{1, m}$$

4.2. Moving average method

The moving averages are simple arithmetical means, calculated from a certain number of terms. The number of terms from which a moving average is calculated, is deduced from the chronogram of the function, being equal with the number of subperiods between two points of minimum or two points of maximum (see table 2).

Table 2. Method of moving averages. Calculus principle

Period (i)	Subperiod (j)	$y_t = y_{ij}$	$\overline{y}_{ij}$	$\overline{\overline{y}}_i$	k_{ij}	k_j	k_j^*	$y_t^* = \frac{1}{k_j^*} \cdot y_{ij}$
0	1	2	3	4	5	6	7	8
	I	y_{11}						
1								
	II	y_{12}						
			$\overline{y}_{2,5}$					
	III	y_{13}		$\overline{\overline{y}}_3$				
			$\overline{y}_{3,5}$					

	IV	y_{14}		$\overline{\overline{y}}_4$				
2	I	y_{21}						
	II	y_{22}						
	III	y_{23}						
	IV	y_{24}						
3	I	y_{31}						
	II	y_{32}						
	III	y_{33}						
	IV	y_{34}						

Generally, the number of terms from which the moving averages are calculated is equal with the number of annual subperiods, respectively m.

In case in which the moving averages are calculated from an even number of terms, the following stages are passed through:

- the calculus of the provisional average:

$$\overline{y}_{2,5} = \overline{y}_{1.2,5} = \frac{y_1 + y_2 + y_3 + y_4}{4}$$

$$\overline{y}_{3,5} = \overline{y}_{1.3,5} = \frac{y_2 + y_3 + y_4 + y_5}{4}$$

Because these averages do not quantize the level of the phenomenon for a certain period of time the centring operation is necessary in order to calculate the definitive moving averages ($\overline{\overline{y}}$), that centre the provisional averages on the time periods of the series- on the trimesters of the years:

$$\overline{\overline{y}}_3 = \overline{\overline{y}}_{1.3} = \frac{\overline{\overline{y}}_{1.2,5} + \overline{\overline{y}}_{1.3,5}}{2}$$

$$\overline{\overline{y}}_4 = \overline{\overline{y}}_{1.4} = \frac{\overline{\overline{y}}_{1.3,5} + \overline{\overline{y}}_{1.4,5}}{2}$$

The provisional seasonality coefficients (k_{ij}) are calculated as a ratio between the real values (y_{ij}) and the values of the moving averages ($\overline{\overline{y}}_{ij}$) with the relation:

$$k_{ij} = \frac{y_{ij}}{\overline{\overline{y}}_{ij}}.$$

Because these seasonality coefficients have different values from one year to another for the same period, the seasonality coefficients (k_j) are calculated as simple arithmetical means from the provisional coefficients (k_{ij}) on periods.

$$k_j = \frac{\sum_{j=1}^{m} k_{ij}}{m}$$

This is necessary because it is considered that seasonality is rigid and consequently constant on time subperiods.

The four seasonality coefficients must respect equality:

$$\sum_{j=1}^{m} k_{ij} = \text{m.}$$

Because of the additional approximations, the condition is not respected and, consequently, the coefficients (k_j) will be corrected. The correction consists in:

$\sum_{j=1}^{m} k_{ij}$ =a≠m$\Rightarrow k_j^* = k_j * \frac{m}{a} \Rightarrow \sum_{j=1}^{m} k_j^* = m.$

The deseasonalized values y_t^* or the corrected series of seasonal variations are calculated with the relation:

$$y_t^* = \frac{1}{k_j^*} y_{ij} = \frac{1}{k_j^*} y_t$$

$$\sum_{t=1}^{n \cdot m} y_t^* = \sum_{t=1}^{n \cdot m} y_t \quad \text{(the principle of the equivalence of areas)}$$

4.3 The analytical tendency method

This procedure consists in estimating the values of the tendency of the phenomenon with an adjustment function, specified for the real values of the phenomenon (y_{ij}), and then the seasonality coefficients (k_j) will be calculated according to the same principles as in the previous cases.

The application of this procedure consists in making the following operations:

1. specification of the adjustment function (one can suppose that the evolution of the phenomenon can be described with a linear seasonality function y_t= a+bt;
2. the estimation the the parameters of the adjustment function is made on the basis of the application of the method of least squares (M.C.M.M.P).
3. $$F(\hat{a},\hat{b}) = \min \sum_{t=1}^{T} (y_t - \hat{Y}_t)^2 = \min \sum_{t=1}^{T} (y_t - \hat{a} - \hat{b}t)^2$$
$$\frac{\partial F(\hat{a},\hat{b})}{\partial \hat{a}} = 0 \Rightarrow T\hat{a} + \hat{b}\sum t = \sum y_t$$
$$\frac{\partial F(\hat{a},\hat{b})}{\partial \hat{b}} = 0 \Rightarrow \hat{a}\sum t + \hat{b}\sum t^2 = \sum y_t \cdot t$$
4. calculus of the adjusted values of the series: $\hat{Y}_t = \hat{a} + \hat{b}t$
5. calculus of the provisional seasonality coefficients: $k_{ij} = \frac{y_{ij}}{\hat{Y}_{ij}} = \frac{y_t}{\hat{Y}_t}$
6. calculus of the seasonality coefficients k_j - of the seasonal component in relative form: $$k_j = \frac{\sum_{i=1}^{n} k_{ij}}{n}$$
7. calculus of the deseasonalized values, $y_t^* = \frac{1}{k_j^*} y_{ij} = \frac{1}{k_j^*} y_t$

the seasonal component, as well as the time series values C.V.S. can be calculated also on the basis of seasonality, s_j, expressed in absolute values. The seasonalities s_j are calculated, as an arithmetical means of the differences $(y_{ij} - \bar{y}_i)$, on each year: $s_j = \frac{1}{n}\sum_{i=1}^{n}(y_{ij} - \bar{y}_{ij})$. If $\sum_{j=1}^{m} s_j = 0$ these values are maintained.

If $\sum_{j=1}^{m} s_j = a \neq 0$, s_j is corrected, thus: $s_j^* = s_j - \frac{a}{m} \Rightarrow \sum_{j=1}^{m} s_j^* = 0$. In this case, the deseasonalized series is determined with the relation: $y_{ij}^* = y_{ij} - s_j^*$.

b) The adjustment function of the tendency of the phenomenon is deduced on the basis of C.V.S., that is the time series corrected by the seasonal variations, also denominated deseasonalized series.

In case in which the seasonal component is estimated on the basis of the tendency function, the series is estimated through the initial model.

c) The verification of the correctness of the model is made as in the case of the unifunctional model.

d) After the estimation of the three components, the econometric model may be used at the estimation of the future values of the phenomenon.

If h=1,2,....,l, where 1 is the prognosis horizon, the real value of the phenomenon in the period t+h va fi/ will be: $y_{t+h} = s_j + \hat{Y}_{t+h} + u_{t+h}$,where the three components are estimated through:

$\hat{Y}_t = \hat{a} + \hat{b}(t+h)$

L($\hat{u}$)=N(0, $s_{\hat{u}}$), from where is deduced that:

$$\in (s_j + \hat{Y}_{t+h} \pm t_\alpha s_{\hat{Y}_{t+h}})) = 1 - \alpha$$

P(yt+h *sau*

$$P(y_{t+h} \in \lfloor k_j \cdot (\hat{Y}_{t+h} \pm t_\alpha \cdot s_{\hat{Y}_{t+h}}) \rfloor) = 1 - \alpha$$

that is the real value of the phenomenon is estimated through a trust interval, having the significance threshold equal to α.

5. THE SOFTWARE PRESENTATION OF THE SYSTEM OF PROGNOSIS OF THE QUANTITIES OF WASTE GENERATED WITHIN A GIVEN PERIOD.

5.1 The general architecture of the system

Within the system the following types of data are defined:

- data regarding the waste management (monitored zones, waste, pollution sources, waste storages, reworking facilities);
- data regarding the environment protection (quality envoronment parameters: air, water, ground);
- spatial data (telematic maps).

The system database is a database distributed on the following levels:

- the central database server (SQL server Microsoft);
- the local database servers (S.G.B.D. MySQL).

5.2. Conceptual database scheme

For the logical data modelling it begins from the entity diagram- general relation of the system represented in figure 1.

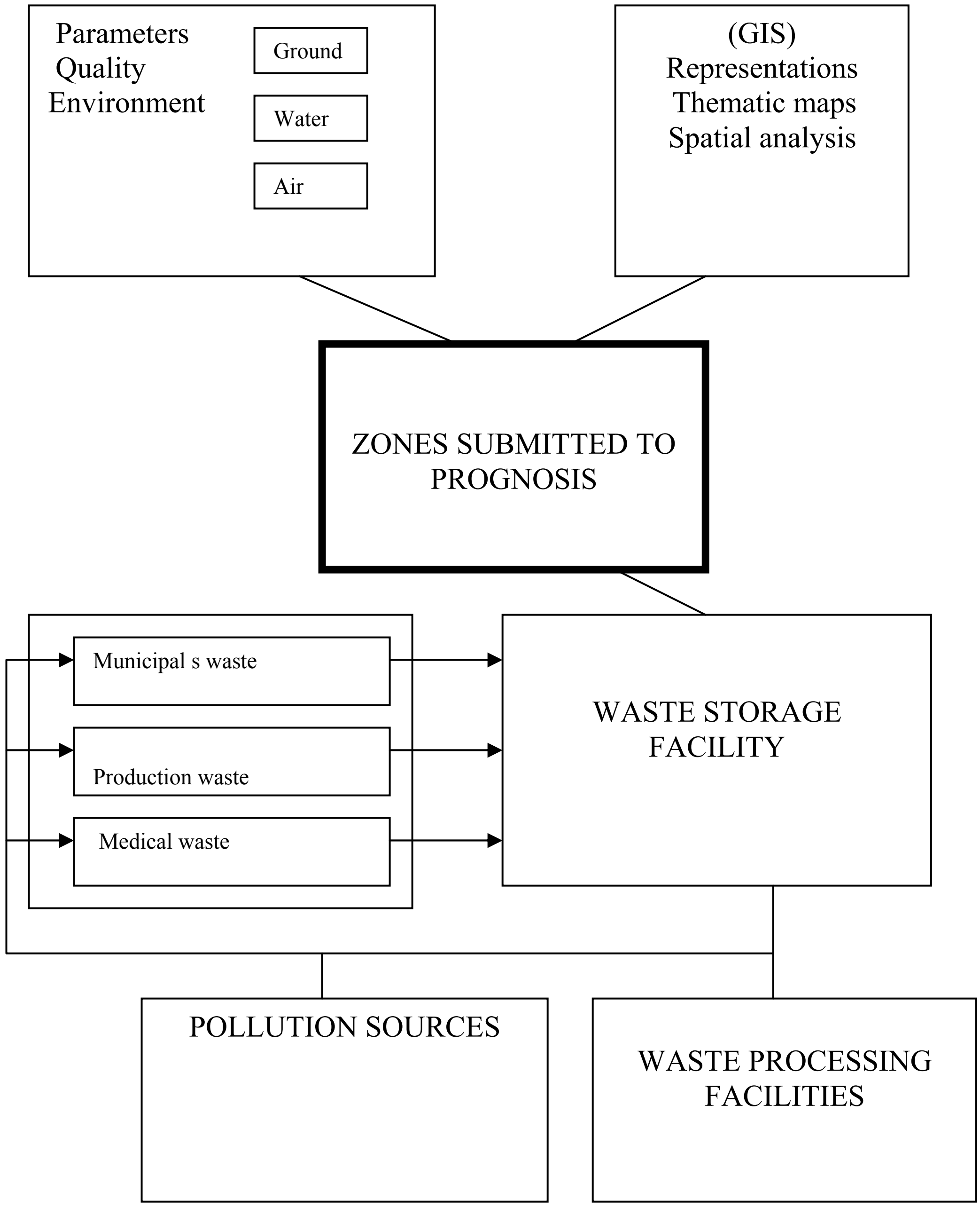

Figure 1 Conceptual Database Scheme

6. CONCLUSIONS

In this study the authors presented a system of prognosis of the quantities of waste collected in a given period. The main objective of the system consists in monitoring the zones affected by the uncontrolled storage of waste by using the newest informational and communication technologies, by developing an electronic GPS/GIS system of geographical positioning. The database of the system is distributed on the following levels: database server (SQL Microsoft server) and the local database servers (using the MySQL S.G.B.D). It may be accessed from any location in the world and it aims at developing a monitoring system, endowed with sensors and transducers, capable of measuring state measures of the ecologic system (municipal waste (including household waste), industrial, agricultural, production waste, packaging waste, biodegradable waste, etc). The measures thus gathered will be converted into numerical values that will be stored in the database of the system. Given that the environment data is gathered periodically (at different time periods), the database of the system is a temporary database, that means that besides the current data, the database also contains historical data, and the **time** factor (attribute) is essential.

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