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# The assessment of sanitation and water quality in outdoor swimming pools in Tirana, Albania

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**Abstract:-** The aim of the study is to assess sanitary conditions of the outdoor pools as a necessity for the health safety of their users. Objectives. The evaluation of physico-chemical, microbiological and management indicators, as well as the determination of risk factors on citizens' health. Material and methods. The study was conducted within a period of 3 years in Tirana outdoor pools. There were analyzed physico-chemical indicators that are usually controlled in swimming pools such as temperature, free chlorine, pH, ammonium ions, alkalinity, hardness, index digestion, as well as microbiological indicators such as total and fecal coliforms, fecal sptreptococus, pseudomonas aeruginosa and staphylococcus aureus. For taking and analyzing the samples are used ISO, EN and SSH methods. All used reagents were on degrees for analysis. Sampling is taken in different hours and days of the week. There were also checked maintenance and management indicators. The results showed that free chlorine is in values above the norm, with the exception of early morning hours. Only one of the pools uses superchlorination. Microbiological contamination is present and is mainly of fecal type in over 70% of samples. In general pools are overcrowded. Conclusion: Chemical and microbiological risk is present in our pools and therefore they have a direct impact on the health of their users.

**Keyword:-** Free chlorine, management, microbiology, health.

## I. INTRODUCTION

Social-economic changes brought about the need to increase the number of recreational place, swimming pools. After 1995, it began the construction of many outdoor pools and currently in our country there are operating over 100 pools and old rules about pools went out of function. For hygienic assessment it is important risk factors assessment.

Assessment of risk factors is assessed by microbiological and chemical hazard in the water of swimming pools to have healthy pools.

**Microbiological hazard**

The risk of disease or infection is associated with fecal contamination of water. Fecal contamination may be due to feces released by brushing or polluted water source. The main representatives of fecal contamination are: E. coli, fecal streptococcus, Cryptosporidium.

No fecal pollution includes human spills (eg, vomiting, and nasal mucus, saliva, sweat of skin) in the pool. Among the representatives of nonfecal microorganisms we can mention: Pseudomonas aeruginosa [1] [2], Staphylococcus aureus that are found in pools and are important ingredients in the normal microflora of skin, ears, nous. These microorganisms can cause skin infections such as burns, wounds etc.

**Chemical hazard**

Chemicals found in pool water, constitute the chemical risk and they end up in pools from the supply source, bathing and disinfection process. The chemical released from bathing and the ammonia according to reaction Hydrolysis of urea under the action of urease enzyme [3] is accomplished as in the following reaction:

$$(NH2)\ 2\ CO + H2O \rightarrow CO2 + 2NH3\ (1)$$

Disinfection chemicals are formed by the reaction [4]

$$NH3 + Cl2 \rightarrow HCl + NH2Cl\ (2)$$

Chloramines cause eyes and skin irritation to pool users. The removal of chloramines is performed from superchlorination process [5].

Assessment of chemicals is carried by physico-chemical analysis of water in swimming pools.

## II. MATERIAL AND METHODS

For conducting this study are taken samples and are analysed six outdoor pools in the city and suburbs of Tirana, frequented by all ages, for a period of three years.

The pools in the study were selected based on the attendance by their users, different ages, various sources of water supplies and disinfection methods used. During the study period there were analyzed 360 samples for physico - chemical indicators and 60 samples for microbiological indicators.

Samples were taken on different days during the week, on the weekend when the attendance is on the maximum, avoiding days with unfavorable weather conditions for bathing. In pools together with sampling there were recorded also the management and maintenance conditions.

The methods used for analysis of physico - chemical indicators are as follows: ISO EN SSH methods. For microbiological indicators the method used is filtrante membrane (MF) according to standard ISO 9308-2:1990, ISO 9308 -1 : ISO 9308-3

Apparatus used were: spectrophotometers DR / 2000 HACH with accuracy of ± 2 % with direct reading. pH- meter type 320 WTW exactly 12:01 ± 1, conductivity HACH type model 44600 with accuracy of ± 1 % of reading .

For microbiological analyzes, the instruments used were: membrane filtration device , counter type colonies Stewart ; ultraviolet CAMAG reading rooms ; Stereo Microscopes - Nikon , thermostat 44 º C incubation ± 0.5 º C autoclave for sterilization of tools.

During the analysis are used only analytical grade reagents for analysis. Reagents used were : N , N-Diethyl -1- 4- phnylenediamine ( DPD1 ) Jodat potassium chloride ,the pH buffer solutions 4,7,10 3M , KCl solution, 0.025 M EDTA solution , NH4Cl ammonium chloride and ammonium hydroxide NH4OH , 0.1N hydrochloric acid, Nessler reagent.

The quality control of water in physico-chemical analysis was carried out by participating in testing interlaboratorike international. ("Proficiency IPA 2011 PT 2 testing Drinking Water ") Laboratory performance was evaluated on the basis of statistical methods according to ISO 13528, 2005 based on Z-score. [6] [7]

$$|Z| \leq 2 \text{ satisfactory result;}$$

Our results were satisfactory, with values of $|Z| \leq 2$

## III. RESULTS

Assessment of risk factors for outdoor pools is accomplished through:

**1 Physico-chemical indicators** of water in the swimming pools.
The main indicators are

● **Free chlorine.** Among the most important indicators affecting sanitation water is free chlorine in pools, which operates by destroying organisms.

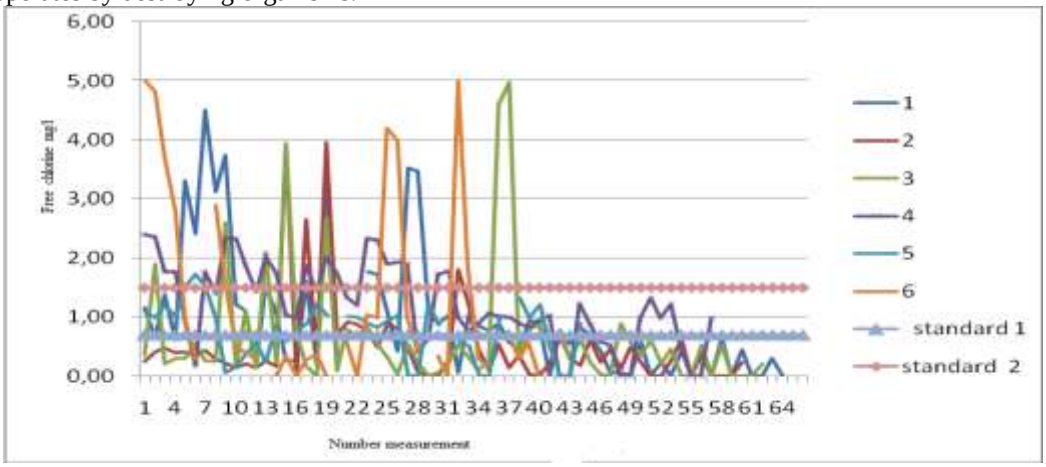


Figure No 1. Values of free chlorine for outdoor swimming pools

From the above figures we see that free chlorine values were lower than standard minimum value (0.7 mg / l) and in higher values than the maximum permissible standard (1.5 mg / l). [8] The reduce the value of chlorine in swimming pools comes, among other things by the rays of the sun, because none of the pools are not used for chlorine stabilizer (cianurik acid). [9].

●**The concentration of hydrogen ions (pH)**
The process of chlorination to be effective parameter pH is an important indicator

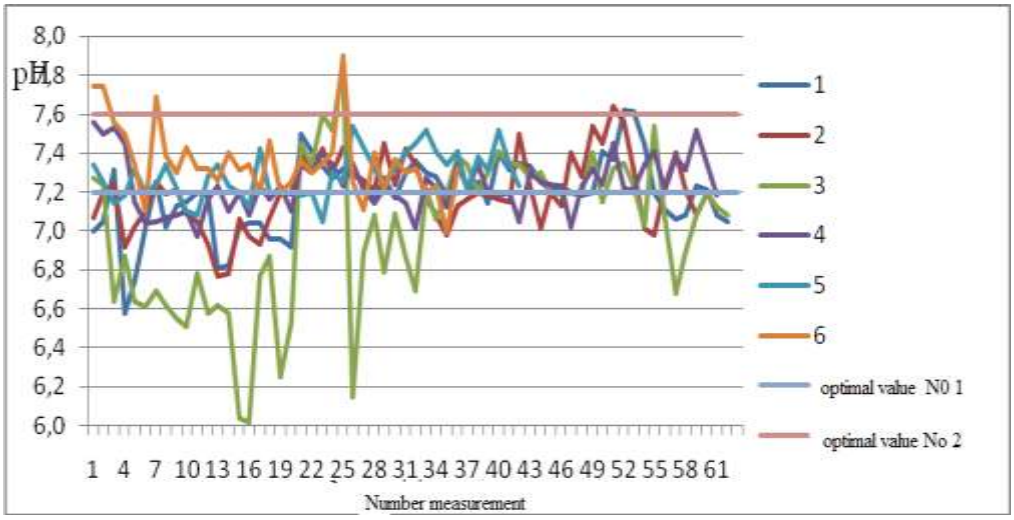


Figure No 2. Values of pH for outdoor swimming pools

pH values are generally within 6.5-8.5 standard values. Optimum pH values for a better chlorination process are considered in interval 7.2-7.6. Only pools No. 3 presents values lower than optimal and in some cases even below the minimum allowed values. This is the pool where children do sunbathing. In this pool chlorination process is not effective as result of low pH values.

● **The concentration of ammonium ions** is one of the parameters that indicates water pollution in pools.

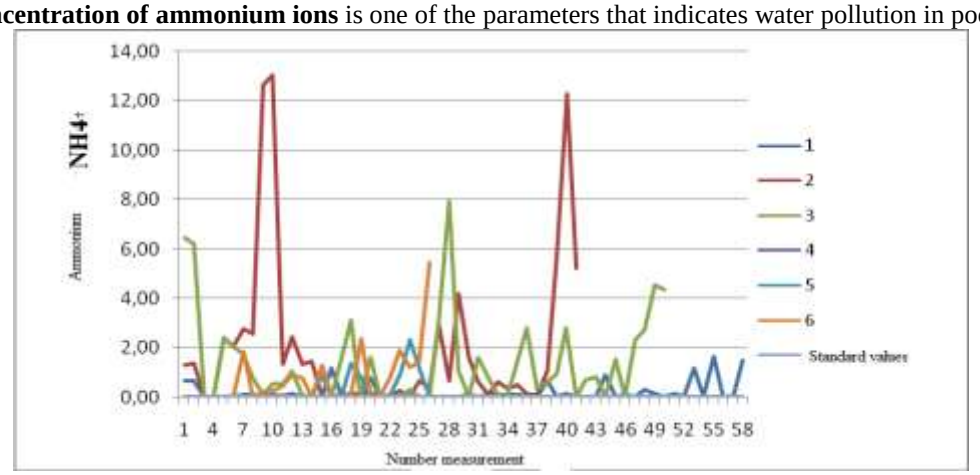


Figure No 3 Values of ammonium ions concentration in outdoor swimming pools.

In all studied pools there are ammonium ions content above the standard values (12:05 mg / l), but it seems more significant in pools No.1, 2, 3, 4 and 6. This shows the complete lack of chlorination and not implementation of rules by pool users.

● **Suspended mater** in pools in the study generally is within the standard values
(4 mg / l), and this is due to the fact that that is an indication that is perceived by pool users.

●**Total alkalinity** is a parameter that should be monitored in water pools because it helps preventing the wide variation of pH when a small amount of acid or base is added to the pool.

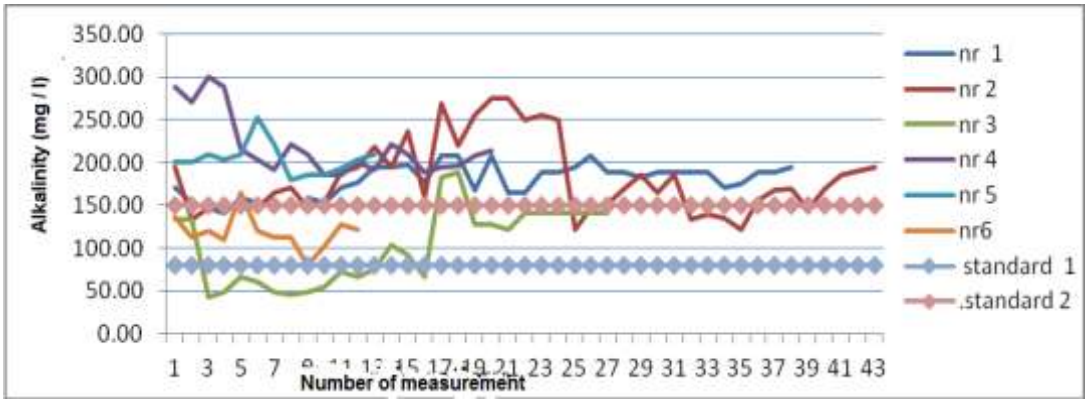


Figure No 4 Alkalinity values expressed in calcium carbonate swimming pools

A large number of measurements of alkalinity values are outside the recommended range (80-150mg / l calcium carbonate).

All swimming pools in the study are supplied with well water and none of them makes any chemical treatment of the water supply to adjust alkalinity.

Index of alkalinity is not controlled and is not at all taken into consideration by operators of water treatment in swimming pools.

●**Langelier Saturation Index parameters** is determined after studying chemical water pools Langelier calculated according to the formula (Index = pH + digestive TF + CF + AF -12.1).

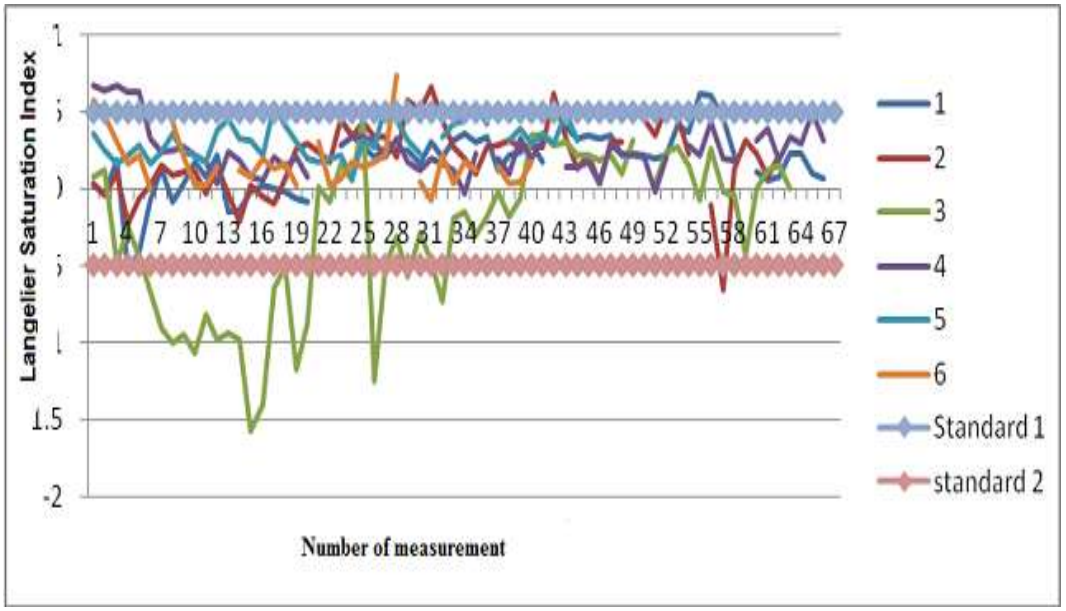


Figure No 5 Saturation Index values in outdoor pools.

The figures show clearly that in outdoor swimming pools there are Saturation index values within the balanced water indicators (+0.5, - 0.5), except the pool No. 3 that is outside of balancing values (<-05).This shows that there is corrosive water pools.

**2 Microbiological indicators for outdoor swimming pools.**

Microbiological tests in water pools used to determine the sanitary quality and help for bathing health safety.They are indicative of the efficiency of the disinfection process. In pools with chemical parameters on the rate of pollutants, microbiological tests are done more frequently than recommended. Microbiological tests were performed simultaneously with physico-chemical analysis. Below is the microbiological load in the form of tables in these pools.

Table No 1 Values of total coliforms in ourdoor pools.

| Number of measurements | 1 | 2 | 3 | 4 | 5 | 6 | standard values (ufc/100 ml) |
|---|---|---|---|---|---|---|---|
| 1 | 0 | 1 | 1638 | 0 | 0 | 504 | 0 |
| 2 | 4 | 504 | 24 | 0 | 630 | 200 | 0 |
| 3 | 32 | 4 | without counting | 1 | 787 | 608 | 0 |
| 4 | 56 | 0 | without counting | 0 | 26 | without counting | 0 |
| 5 | 2 | 14 | without counting | 0 | 4 | 5 | 0 |
| 6 | 2 | 10 | 24 | 1 | 19 | without counting | 0 |
| 7 | 8 | 18 | 1 | 1 | 0 | 134 | 0 |
| 8 | 2 | 24 | without counting | 2 | 154 | | 0 |
| 9 | 80 | 1 | 630 | | | | 0 |
| 10 | 34 | without counting | 0 | | | | 0 |
| 11 | 45 | 230 | without counting | | | | 0 |
| 12 | | 0 | 214 | | | | 0 |
| 13 | | without counting | without counting | | | | 0 |

From the table it is clear there is the presence of total coliforms in all pools, but more significant is to pools No. 1, 2, 3 and 6.where pool No. 3 (children) resulting more contaminated . In the table below are the results for the fecal coliforms microbial load.

Tabele No 2 Fecal coliforms values in outdoor pools.

| Number of measurements | 1 | 2 | 3 | 4 | 5 | 6 | standard values (0 (ufc/100 ml |
|---|---|---|---|---|---|---|---|
| 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| 2 | 0 | 12 | 10 | 0 | 0 | 20 | 0 |
| 3 | 0 | 1 | 580 | 0 | 6 | 28 | 0 |
| 4 | 4 | 0 | 86 | 0 | 1 | 304 | 0 |
| 5 | 0 | 6 | 52 | 0 | 3 | 2 | 0 |
| 6 | 1 | 5 | 10 | 0 | 0 | 556 | 0 |
| 7 | 2 | 8 | 58 | 1 | 2 | 18 | 0 |
| 8 | 1 | 10 | 0 | | | | 0 |
| 9 | 1 | 0 | 0 | | | | 0 |
| 10 | 1 | 58 | 252 | | | | 0 |
| 11 | 1 | 252 | 256 | | | | 0 |
| 12 | | 58 | 28 | | | | |
| 13 | | | 187 | | | | |

From the above table it is clear that fecal coliforms are present in all the pools, indicating a bacterial contamination disallowed by the standard.

This contamination results in relatively high value to pools No. 2, 3, 6 and in lower value to pools No. 1, 4 and 5. These results are interpreted values besides chemical indicators point to mismanagement of water quality of pools and bathing by misuse. The rate for all microbiological indicators should be 0 ufc/100 ml.
The following table presents the values for Pseudomonas aeruginosa.

Tabele No 3 Pseudomonas aeruginosa values outdoor pools.

| Number of measurements | 1 | 2 | 3 | 4 | 5 | 6 | standard values (0 (ufc/100 ml |
|---|---|---|---|---|---|---|---|
| 1 | 0 | 0 | 530 | 0 | 0 | 0 | 0 |
| 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 3 | 0 | 0 | without counting | 0 | 168 | 1 | 0 |
| 4 | 0 | 1 | without counting | 1 | 0 | 0 | 0 |
| 5 | 0 | 0 | without counting | 0 | 0 | 0 | 0 |
| 6 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 7 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| 8 | 0 | 0 | 0 | 0 | 0 | | 0 |
| 9 | 0 | 0 | 0 | | | | 0 |
| 10 | 1 | 0 | 1 | | | | 0 |
| 11 | 0 | 0 | 0 | | | | 0 |

The table appears Pseudomonas aeruginosa is high value to pool No.3 that indicating insufficiency of the disinfection process

Fecal Streptococcus is caught in pools high value to No. 2 and 3, resulting in general problematic, apparently from more frequent attendance and mismanagement

**3 Methodology of statistical analysis of survey data**

The data were analyzed by statistical package Mini tab 16.1. Variables were tested for normal distribution by Anderson Darling test and non-parametric tests were used in cases where the distribution was abnormal. To assess the relationship between variables are used Pearson parametric and Spearman non-parametric correlations. The linear regression was used to assess the trend of $Cl_2$ and non-parametric Mann-Whitney test to compare the amount of $Cl_2$ by time. ANOVA-One way test was used to compare mean values of variables continue, $Cl_2$, $NH_4$. The level of significance was set for p values $\leq$ 0:05. Statistical tests are two-sided. The data and results are expressed with tables and graphs.

The boxplote are used in our processing the statistical comparison.

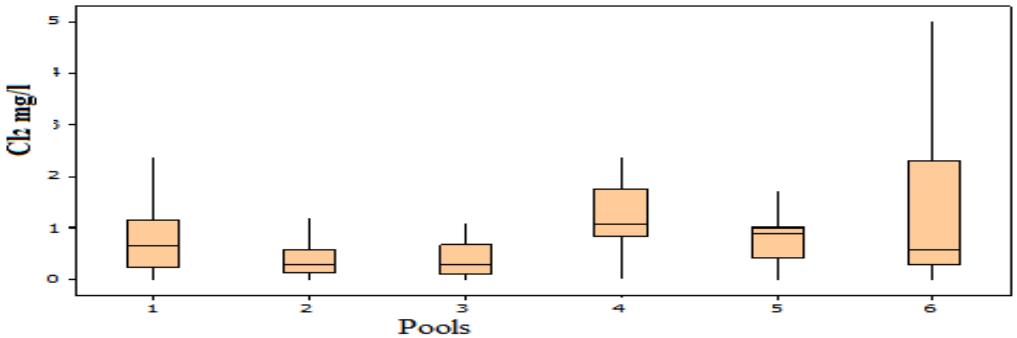


Figure.6 Boxplotet of free chlorine for outdoor swimming pools.

The values ammonium ions are compare between pools using boxplotet.

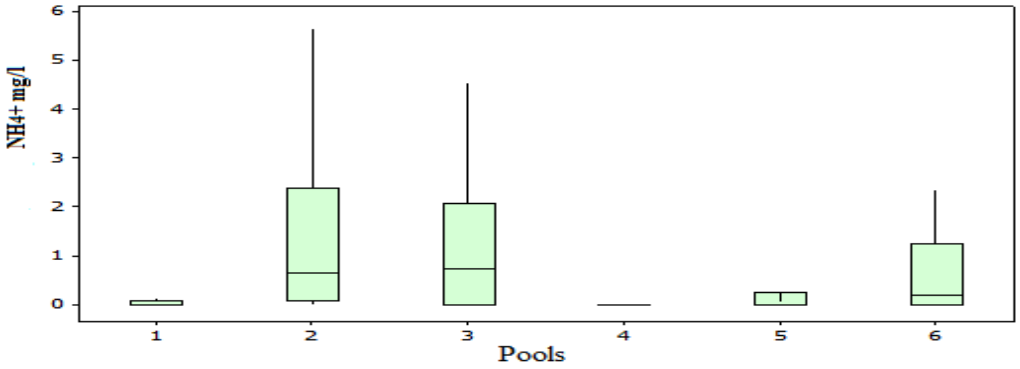


Figure 7 Boxplotet of ammonium ions for outdoor swimming pools.

The highest amount of ammonium $NH_4^+$ observed in pool No. 3 (M = 1.3 ± 1.8 SD) no statistically significant difference with other pools (ANOVA F = 1:32 p = 0.068)
Pool No. 4 has the value of ammonium rate values. Pool No. 3 has the largest amount of ammonium ions as frequented by children.

**Correlation of free chlorine $Cl_2$ in pools with microbiological pollution.**

Below we provide graphical presentation of statistical analysis results for the correlation between free chlorine and indicators of microbiological load in pools analyzed in the study (total coliform, fecal coliform, Staphylococcus aureus, Streptococcus fecal, pseudomonas aeruginosa). Taking as example pool No. 1. The ordinate axis shows the number of organisms per 100 ml sample respectively, while the axis of the X-axis is presented free chlorine concentration in mg / l

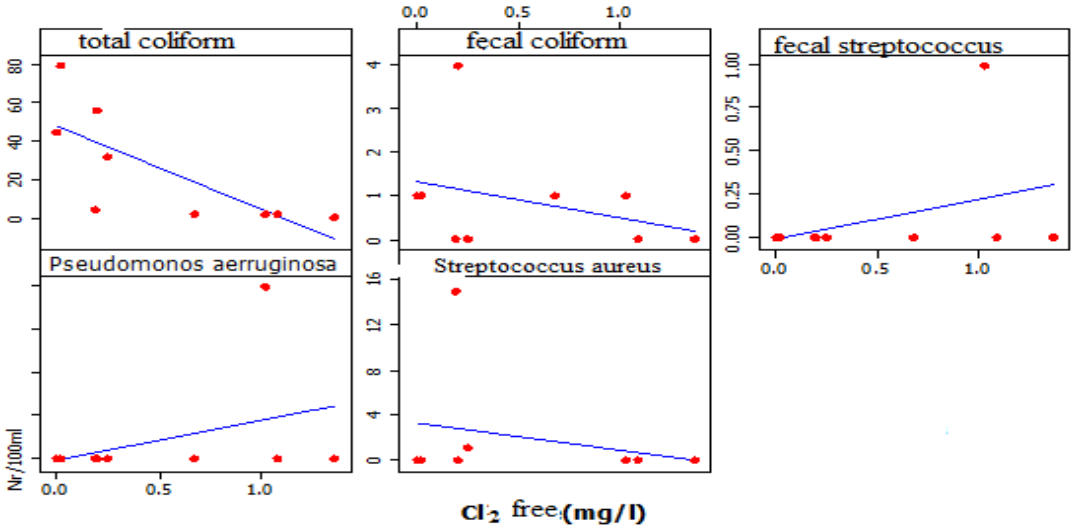


Figure No 8 Correlation of free chlorine $Cl_2$ with microbiological pollution, in pool No.1.

The figures above see for fecal streptococcus, pseudomonas aeruginosa and in some cases to Streptococcus aureus is pozitiv.This correlation can be explained by the fact that these organisms are resistant to free chlorine in relatively high concentrations and derive the necessity of superchlorination process.

## IV. DISCUSSIONS

- Free chlorine is the main parameter estimates disinfection of swimming pools.

All swimming pools have manual chlorination system and can not dosing chlorine in swimming pools in moment people attending are in the basin, after throwing disinfectant often performed in the swimming basen This is a problem related to the way of their design and construction. In swimming pools, free chlorine value is optimal only in the early hours of the morning.
One reason for the decrease in the value of free chlorine for swimming pools is the presence of sunlight. To

avoid this problem you should use chlorine stabilizers, but in none of the pools not used chlorine stabilizer (acid cianurik)

- In all pools lacks management of chlorine depending on bathing load.
- The presence of ammonium ions values and microbial load in the pool clearly shows the lack of superchlorination process and follow the rules by users.
- pH values were outside the optimal values so reduce the efficiency of the chlorination process.
- The presence of ammonium ions in pools influences the development of type fecal microorganisms.
- Alkalinity is an indication that is not controlled and not at all taken into account by operators of water treatment in swimming pools.
- Suspended mater is one of the parameters that better managed by the operators of swimming pools , the fact that it has to do with the visual appearance of the water and makes users perceive the quality of the pool water and feel more comfortable . This shows that filtration systems are well-managed in all pools,
- Langelier Saturation Index all the time is beyond value (- 0.5) belonging to the corrosive environment in pools No. 3.
- Microbiological pollution is mainly fecal type: total coliform, fecal coliform , fecal streptococcus , which is related to poor hygiene bathing .
- Area allowed for a user is not managed in almost any pool. This is an important indicator affecting pool water parameters, but significantly exceeded weekends.
- The process of recycling water and fresh water input, performed regularly in all pools. Their water flows once a year and made cleaning baths.

## V. RECOMMENDATIONS

- Design of new pools should consider primary water treatment plant and chemical balancing reservoir for water . It is imperative that the introduction of automatic disinfection at any point of time, free chlorine to be 0.7-1.5 mg / l

- Swimming pools should superchlorination once a week ( this should be done holidays ) .
- Disinfection in the case of limited fecal contamination is carried on the free chlorine concentration of 2 mg / l for 40 minuta and in the case of pollution in the form of diarrhea be performed in free chlorine concentration of 10 mg / l for 22 hours. In these cases the pools kept closed to users until the normal parameters.
- Swimming pools can also use chlorination trichloroisocyanuric acid in tablet form (with 90 % active chlorine) , since it is more resistant to sunlight.

- Swimming pools should apply the methodology of the "auto control " and the identification of concrete data.

- The number of persons on the surface must be such that a person you meet at least 3-4 m2.

- Pool administrators must decide on visible places " internal regulation " of the operation of the pool.

- Keeping regular documentation of risk management across pools will serve to create a national database for monitoring the quality of waters of pools , in order to safeguard the health and security of users .

## VI. CONNCLUSION

Given the findings of the study go to some conclusions

1 Chemical and microbiological hazard is present in our pools and therefore have a direct impact on the health of their users

2. It must use education and promotion of healthy bathing water for both users and their managers.

3. Strengthen the control hygiene and sanitation by health inspectors will directly serve the protection of health bathing and goers pools.

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