Journal of Physical Education and Sports Management
December 2016, Vol. 3, No. 2, pp. 57-77
ISSN 2373-2156 (Print) 2373-2164 (Online)

Published by American Research Institute for Policy Development
DOI: 10.15640/jpesm.v3n2a4
URL: https://doi.org/10.15640/jpesm.v3n2a4

Environmental Quality in Sports Facilities: Perception and Indoor Air Quality

Cristina Cianfanelli[1], Federica Valeriani[2], Saverio Santucci[3], Saverio Giampaoli[4],Gianluca Gianfranceschi[5], Alessandro Nicastro[6], Federica Borioni[7], Gianvito Robaud[8], Nicolina Mucci[9§], Vincenzo Romano Spica[10]

Abstract

Safety and quality in sport environments are ruled by regulations and supported by monitoring tools. An integrated approach to assess environmental air quality in sport facilities can impact on wellness and promote physical activity and healthy life styles in different recreational settings. We review the national and international regulations of indoor air quality in gyms and pools. A field survey was performed in sport facilities using standardized monitoring techniques. Data on air microbiology and thermal comfort were compared with individual perception by a questionnaire. The results obtained are in accordance with other studies and did not reveal major health hazards. However, it is desirable to implement air exchange and monitor microclimate parameters in these facilities. The indoor air quality complies with the national standards for non-industrial premises. The questionnaires showed a general satisfaction for safety and hygiene levels. In conclusion, we provide a state of the art on regulations and environmental markers in sport plants, suggesting an integrated approach for surveillance based on laboratory test and questionnaires data. The whole of the results provides strategies and guidelines for improving environmental quality in sport and recreational settings.

Keywords: IAQ, individual perception, integrated approach, questionnaire, sport facilities.

1 Inail, Department of Technological Innovations and Safety of Plants, Products and Anthropic Settlements, Rome, Italy
2 Public Health Unit, University of Rome “ForoItalico”, Rome, Italy
Inail, Department of Technological Innovations and Safety of Plants, Products and Anthropic Settlements, Rome, Italy
4 Public Health Unit, University of Rome “ForoItalico”, Rome, Italy
5 Public Health Unit, University of Rome “ForoItalico”, Rome, Italy
6 Public Health Unit, University of Rome “ForoItalico”, Rome, Italy
7 Public Health Unit, University of Rome “ForoItalico”, Rome, Italy
8 Public Health Unit, University of Rome “ForoItalico”, Rome, Italy
9Inail, Department of Technological Innovations and Safety of Plants, Products and Anthropic Settlements, Rome, Italy
10Public Health Unit, University of Rome “ForoItalico”, Rome, Italy

1. Introduction

The individual perception of an indoor environment represents a useful tool for assessing livability and usability of sports facilities and for developing strategies for their improvement. Different approaches have been developed to investigate the individual wellbeing such as collecting data by questionnaires or monitoring techniques, in order to assess the reciprocal impact of microclimate, environmental conditions and clothing on physical activity (Nathan, 2013; Leemrijse, 2015).

Other methods include interviews, use of maps and blog focus groups to evaluate the perception of indoor buildings quality, including schools or sport facilities (Kirby, 2013; Moran, 2014). As modern societies spend most of their time in buildings, the indoor air quality, thermal comfort, edifice maintenance, play a relevant role. These parameters assume a particular interest in sport facilities not only because physical activity challenges microclimate perception, but also for the higher expectancies for a healthy environment to practice sport.

Indoor air quality (IAQ) assumes a special meaning in these workplaces, influencing human health and athletic performance (Romano Spica V, 2015). This is an emerging issue for sport hygiene involving a growing number of people and workers in the field of sport. A survey commissioned by the European Commission's Directorate General for Education and Culture (DGEAC) on a sample of 26,788 European citizens, indicated that the people of the Nordic countries are the most physically active in the EU (70% Sweden, 68% Denmark, 66% Finland, 58% Netherlands, 54% Luxemburg), while the residents of the Mediterranean countries, including Bulgaria (78%), Malta (75%), Portugal (64%), Romania (60%) and even Italy (60%) are among those play sporting activities less than once a week (EC, 2014).

Nevertheless, in Italy, this sport industry counts 4.500.327 athletes and 1.016.598 operator, belonging to 64.829 clubs (Coni, 2014). Sports facilities are complex and heterogeneous buildings and they are unique in their kind, for energy consumption, used materials, comfort requirements (Revel, 2014). Moreover, performing sport in healthy environments strengthens motivation in addition to other factors such as age, sex, socio-economic conditions, school, food habits, plant accessibility (Sani, 2012; Eime, 2013; Chen, 2013; Reimers, 2014; Coledam, 2014; Adlakha, 2015; Laxer, 2013).

Athletes can develop respiratory and allergic diseases not only due to the exposure to inhaled pollutants but also to the increased ventilation rate (Sugiyama, 2008). The increase of air flow, with the fact that most of the air is inhaled through the mouth thus avoiding the normal nasal mechanisms for the filtration of soluble particles, allows the pollutants to proceed deeper into respiratory tract (Carlisle, 2001). The most common pollutants detected in these environments include VOCs (Volatile Organic Compounds), fungi/molds, bacteria (Gedikoglu, 2012; Alves, 2013).

Swimming facilities pose an additional problem related to management of water, requiring surveillance on disinfection, humidity and environmental maintenance (WHO, 2006). The present paper reports local and international regulations on IAQ in sport facilities and data from an original pilot study performed in two sport environments.

2. Materials and Methods

The review of regulations and monitoring parameters was performed using online database and search engines. A local pilot study was conducted in two sports facilities in Rome, to apply and test in field environmental indicators. Several samplings points were identified to assess microbiological air quality through active sampler, and microclimate investigations by a data logger with different probes. In addition, in both sites were distributed questionnaires to users and workers, to ascertain the individual perception of the plants quality. Analyses of the water safety and quality were tested in a swimming pool.

2.1. Study area

The first plant (Site I) is a polyvalent sports center, which is the space of sport activity with related grandstands, support services such as dressing rooms, a store, a gym, all gathered in one building in front of an outdoor playground. The second plant (Site II) includes a gym, two fitness rooms, two tanks, a big pool, 25 m length (max depth 3.60 m) and a small pool, 10 m length (maximum depth 0.60 m), where are carried out baby and neonatal swimming lessons.

2.2. Sampling procedure

In Site I six air samplings were conducted at the following points: the secretariat offices, the gym, 3 dressing rooms, and the store. In Site II three air samplings were performed: the big pool, the small pool and dressing room. The studies were carried out between January and May 2015.

2.2.1. *Microclimate.* The instrument used is the HD32.3 data logger (*Delta Ohm LTD, Italy*) which has three probes, thermo hygrometric (temperature and relative humidity), anemometer (air velocity) and globe thermometer (radiant temperature). To determine the individual wellness, the instrument calculate the discomfort indices PMV (Predicted Mean Vote) and PPD (Percentage of Persons Dissatisfied), comparing the environmental data with metabolic and clothing parameters. The PMV is a mathematical function which gives as result a numerical value in the range -3 (feeling too cold) to +3 (feeling too hot), where 0 represents the thermal comfort. The PPD expresses the percentage of dissatisfied people in a particular environment. The tool has been positioned in the sites center, for 15 minutes, with 15 seconds intervals in measurement at the worker's chest height. To evaluate the thermal comfort we referred to standards ISO 7730, 7726, 27243, 7933, 11079, 8996 (Table 1).

PMV	PPD%	EVALUATION OF THERMAL COMFORT
3	100	Very hot
2	75.7	Hot
1	26.4	Slightly hot
0.85	20	Thermal environment within acceptable
-0.5<PMV<0.5	<10	Thermal comfort
-0.85	20	Thermal environment within acceptable
-1	26.8	Slightly cold
-2	76.4	Cold
-3	100	Very cold

Table 1: Reference values of thermal comfort according to ISO 7730, 7726, 27243, 7933, 11079, 8996.

2.2.2. *Microbiological air sampling.* The microbiological air samplingwas performed by SAS (Surface Air System, *VWR International, LLC, and Radnor, USA*), a plate impact active sampler, type slot, using Petri dishes Ø 55mm. The air aspiration volume was 180 L (for 60s) for each sampling.

We used two culture media types: TSA agar medium for bacteria (Tryptic Soy Agar - *Oxoid, Germany*), SDA agar medium (Sabouraud Dextrose Agar - *Oxoid, Germany*) supplemented with Chloramphenicol (*Oxoid, Germany*) for fungi/molds. The TSA and SDA plates were incubated both at 37°C (for 48 hours) and at 22°C (for 72 hours). For each plate, the calculation of the CFU/m^3 was obtained as follows: CFU/m^3 = (MPN/plate x 1000) / air volume (L).MPN/plate was obtained by comparing the CFU of each plate with the conversion table, in attachment to the device manual.

2.2.3. *Analysis of water quality in the pools*. The water of the two swimming pools was sampled using two glass bottles (1L for each sampling) containing Sodium thiosulfate (20 mg/l), necessary to block the action of disinfectants. Following the Italian regulation (Italy, 2003), we have been investigated the following indicators: *Escherichia coli* (ISO 9308-2:2012), *Enterococci* (Enterolert, Quanti-Tray™ test), *Pseudomonas aeruginosa* (Pseudalert, Quanti-Tray™ test), *Staphylococcus aureus* (ISO 6888-3:2003) and was performed the counts at 22°C and 36°C hours. Moreover, were monitored temperature, pH, free and combined chlorine data of the water. The chlorine was analyzed by colorimetric method(Orto-tolidine molecule) for free active chlorine and by DPD method(diethyl-p-phenylenediamine) for free and combined chlorine. Global Index of Microbiological Contamination (IGCM) values have been also computed.

2.2.4. *Questionnaire.* Starting from a previous template developed byan Environment and Consumers Protection Association (Adiconsum Toscana), a specific questionnaire was prepared in order to assess and quantify the level of satisfaction of the Site I visitors, in relation to hygiene and safety of the facility. It was subjected to 44 persons, 14 - 33 year aged. The questionnaire was characterized by two different sections: a structural assessment of the assembly (e.g. maintenance, safety, usability, condition of the equipment) and hygiene assessment (e.g. cleanliness, temperature, humidity). For each question was asked to express an opinion as "dissatisfied", "not very satisfied", "satisfied", "very satisfied". In Site II the questionnaire was proposed to 18 people, selected among the current members of the facility, and it asked the issues should be improved about the suitability of the structure, safety, hygiene, dressing rooms and personal notes. Data collected and analyzed by Excel.

3. Results

In this study, we report an overview of hygiene-related regulations from different countries and tested some indicators and instruments, samplings two sports facilities of Rome. Microclimate parameters, microbiological air quality, swimming pool water quality and the perception of indoor environments by users and employees were considered.

3.1. IAQ regulations in sports facilities.

Several laws and regulations on construction and maintenance of sports facilities are available and relate to safety and public health. The following summary shows several institutions and regulations, involved in IAQ management in sports facilities, in Europe and other countries.

3.1.1. ***Sport facilities.*** The legislation about sports facilities is very heterogeneous and depends on several factors, such as the State organization and the intended use of the facilities. Sports facilities are often polyfunctional buildings, where different type of sport can be carried out, but that can be used also for other purposes such as recreational or leisure activities. Different countries have different approaches. For example, the majorities of sporting facilities in Australia are operated and maintained by local governments, schools (both public and private) and private sector business institutions which include sporting organizations or various commercial operators.

In this nation there is not a unique authority with responsibility for IAQ in indoor buildings and the guidelines are developed by several institutions, such as the National Health and Medical Research Council (NHMRC), the National Occupational Health and Safety Commission (NHMRC) and Standard Australia (SA). To assess IAQ, Australia refers to the guidelines drawn up by the American Conference of Governmental Industrial Hygienists (ACGIH, 1995) and by the Commission of the European Communities (CEC, 1993; Australia, 1997).

In the United States of America (USA), several states have regulations on exposure to indoor pollutants for non-industrial environments. Recommended methods for prevention and remediation have been issued by the Center for Disease Control and Prevention (CDC), Occupational Safety and Health Administration (OSHA), the Environmental Protection Agency (EPA), the American Industrial Hygiene Association (AIHA) and the New York City Department of Health and Mental Hygiene (DOHMH). Guidelines on IAQ are provided by the EPA-supported American Society of Heating, Refrigerating, and Air-conditioning Engineers, ASHRAE (USA, 2012). Health Canada is the administrative authority which decides the sanitary standards for indoor environments in Canada.

In particular, several laws, like the Hazardous Products Act and provincial occupational health and safety acts, are related to the management of biological risk in non-industrial buildings. The legislative framework for IAQ indicated that there is no specific mention of most contaminants present in residential settings. The regulations suggest or require the adherence to the advice of cognizant authorities, including Committee on Environmental and Occupational Health (CEOH), the American Society of Heating Air-Conditioning & Refrigerating Engineers (ASHRAE-Standard 62), and the ACGIH Threshold Limit Values (TLVs), as well as determinations or policies of provincial and territorial labor and health departments (Canada, 2004).

In China, the Ministry of Construction and the China State Quality Supervision-Inspection-Quarantine Administration (SQSIQA) promulgated the "Code for Indoor Environmental Pollution Control of Civil Building Engineering" (GB 50325-2001) where comprehensive standards for IAQ are enunciated. In addition, the China Ministry of Health also issued the directive entitled "Hygienic Norm for Indoor Air Quality", which sets the standards and sanitary requirements for IAQ and the sanitary requirements for air ventilation and purification and useful standard methods (China, 2002).

Moreover, in 2006 was promulgated "A new national design code for indoor air environment of sports buildings", that provided guidelines for indoor airflow of sports buildings in China, including the parameters of indoor air environment in gym and pools, such as air velocity, temperature, humidity and fresh air volume replenishing (China, 2006).

In the Russian Federation, the quality of indoor air in occupational premises is determined by the statute "Occupational Safety Requirements for Working Zone Air", dated 1989. This law establishes the general requirements of the microclimate and sets out the Maximum Allowable Concentration (MAC) of pollutants in the working zone air. The laws on air quality are part of the Russian Federation legal system and are secured in the Constitution. The air quality must be controlled by the 'Goscomgidromet' and the 'Sunepidnadzor' of Russia (Russia, 1997).

Moreover, the attention on the issues regarding indoor environments has led some international scientific organizations, including the World Health Organization (WHO), to provide guidelines for IAQ (WHO, 2010). In South Africa, there is no specific law about IAQ and moreover, in the several acts of the parliament regarding health matters, IAQ does not feature prominently. The Health Act n. 63 of 1977 provides for measures for the promotion of the health of the inhabitants of the republic, hinting of indoor settings, over-crowding and poorly ventilated design as a source of dangers to health (South Africa, 2002).

In Europe, the activities of the Commission of the European Union (UE) have been characterized, over the past twenty-five years, by a growing attention to indoor pollution. The different studies financed in this context have tried to increase the knowledge framework and set priorities or objectives to be achieved (Settimo, 2012). In this context, the member states operate by drawing up national guidelines in coherence to the EU Standards. So, in Finland, guidelines on indoor air control are drawn up in the National Building Code of Finland, where are explained all the regulations about indoor climate and ventilation (Finland, 2010). In the Netherlands, the guideline values are established as values for the IAQ in homes, but also offices, schools, recreational environments can be involved. The recommended values are based on the Maximum Permissible Risk, MTR (Netherlands, 2007). In France, the government established in 2001 the Observatory for Indoor Air Quality (OQAI), which aims to draw up an inventory of indoor air pollutants and their determinants. In addition, French Agency for Food, Environmental and Occupational Health & Safety (ANSES), an administrative public establishment which provides assessment for veterinary medicinal products, pesticides, biocides and chemicals, in 2004 has developed IAQ guideline values (IAGVs), based on health criteria (France, 2011).

In different countries, additional indications may be available for each sport, even if the International Olympic Committee and the Sport Federations represent a main source of information at least for athlete's official competitions. However, the diffusion of sport and movement activity as a WHO priority for prevention in populations of different ages and health conditions poses the question of quality standards in gym, pools and other environments dedicated to physical activity. In Italy, the reference standards for safety of sport facilities have been established by the Ministry of internal affairs, by CONI (Italian National Olympic Committee) and by the Welfare and Occupation Ministry.

The Decree of the Ministry of Internal Affairs 18/03/1996, supplemented by Ministerial Decree of 06/06/2005 (Italy, 2005), considers different aspects to ensure a good security level, determining for example, the characteristics of the emergency space, ways out, seating, changing rooms, electrical system, structures and furniture, fire regulations and other standards. Relating to sports facilities buildings, was enacted directive CONI n. 1379 of 25 June 2008 (CONI, 2008), which provides specific references to air quality, aspect not taken into account by previous decrees. For example, it gives recommended values as regards the microclimatic parameters (ventilation, temperature, relative humidity). Regarding the occupational aspects, the decree n°81 of 2008 (Italy, 2008) encloses all the rules relating to health and safety at work and all the rules for the safe construction and maintenance of the workplaces.

3.1.2. *Natatorium facilities.* The legislation at international level regarding swimming pools is very varied and heterogeneous. The difference is closely linked to the different approaches of individual health authorities which are related to the different social, economic and cultural needs of each country. In the USA there are not federal health standards, but the requirement of design, construction and management of the pools must be authorized by the municipal authorities. Among the relevant social principles is included easy access to a swim structure for all kind of population groups (e.g. elderly, disables).

US health authorities entrust to the managers and professionals involved in the management of pools the responsibility to apply the principles of HACCP (CDC, 2003). In Canada, hygienic issues are regulated by legislation drawn up in 2007, establishing the water quality criteria and obligations for managers of indoor and outdoor swimming pools used for swimming, sport or relaxation (Canada, 2006).

Similarly in Australia, the legislation on swimming pools, dated 1990 (Australia, 1990) and revised by the Act of 1992, legislates in different fields of application, including even thermal pools, basins or similar environments (Australia, 1992). In Egypt, the principal legislation relating the control of swimming pool is the "Egyptian standards no. 418/1995", which establishes the microbial indicators and the physical–chemical parameters for water control (El-Salam, 2012). Within the European Union Countries, the situation is very diverse and heterogeneous. The directive 2006/7/EC (Council of Europe, 2006), concerning the quality of bathing waters, has been historically a great social impact on Member States and has greatly influenced the approach to the regulation on matter pools, such as establishing the basic parameters for the evaluation of quality of bathing and recreational water and setting the necessary organization and nature of official controls on water.

In the transposition of the directive into their national legal systems of the Member States, a number of situations have occurred. Some countries (e.g. Belgium, Finland, Germany, Greece, Ireland, Luxembourg, Portugal, United Kingdom) have included in the same standard on bathing waters, all measures deemed necessary for public toilets, thermal baths and pools, specifying the nature of the controls needed for such places. In France, the current legislative framework on swimming pools is based on the Public Health Code. Moreover, the National AgencyforHealth Food Environment and Labor (ANSES) in 2010 published a document on health risks in pools (France, 2006). In United Kingdom, the Health and Safety Executive (HSE) is the authority competent concerning the pools matter in connection with local authorities and schools.

This institution in 2008, with the Health Protection Agency (HPA), has published guidelines on the control of the risk of infection in pools. These protocols are designed to improve the understanding of microbiological hazards and give advice on risk management (UK, 2006). Similarly, since 2005 in Ireland, pools must be managed in accordance with "Safety, Health and Welfare at Work Act" (Ireland, 2005). In addition, specific guidelines, with criteria and more detailed information, have been outlined to help managers in the task (Ireland, 2010). In Germany, technical requirements for the management of the pools are summarized in DIN19643, which ensures the hygiene safety standards in the pools, saunas, hot tubs and spas (Germany, 1997). In Italy, the current reference point about construction, maintenance and sanitary surveillance of pools is the Agreement of 16 January 2003 (Italy, 2003), between the Minister of Health and the Regions.

The text provides the requirements for the water control, in particular those related to temperature and pH, the use of disinfectants (Cl_2, ozone), the microbiological values and standard control. However this agreement has no legislative value, but it is only a political manifestation of intent, and all Italian regions have to join and adapt it to local needs and hygiene objectives within a public health perspective (Italy, 2007; Liguori, 2013; Giampaoli, 2012).

3.2. Microclimate, microbiological air sampling and IAQ evaluation.

Table 2 shows the results obtained in the two sites respect microclimate and microbiological air quality. The standard methods reported in different local or international regulations or previous studies revealed effective and informative. In particular, data on temperature, air velocity, relative humidity and PMV, PPD and IGCM values are reported. In Site I the temperature was around 16°C. The PMV values are negative in all environments, except the Gym (4.9) and the Store (0.6). The PPD values are similar in the Gym (100%), Dressing Room 2 (99%) and Dressing Room 3 (93%). In Site II, the temperature is around 27°C. The PMV values range from 1 (Dressing Room) and 1.3 (Big and Small pool); PPD is similar in the three environments, with a mean of 35%. We referred to the guidelines of “American Conference of Governmental Industrial Hygienists” of 1995 (ACGIH, 1995) for the evaluation of IGCM index (Table 2).

In the Secretary and in the Dressing Room 1 of Site I the IGCM is intermediate; the Dressing Room 2 has the highest index of contamination; in others environments is low. In Site II, Big pool and Dressing Room have both an intermediate pollution degree; the small pool low one. In Table 3 is shown the IAQ evaluation in the two sites referring to the guidelines drawn up by "European Collaborative Action" of 1993 (CEC, 1993), which established the guidance ranges of air contamination for non-industrial indoor environments. In Site I, air quality shows bacterial pollution degrees rather heterogeneous in the various sampled environments: very low values at 22°C in the Dressing Room 3 and Store; high values at 37°C in the Secretary and Gym; very high at 37°C in the Dressing rooms 1 and 2. The fungal growth had a more constant trend, in fact all the environments show intermediate values. In Site II, bacterial pollution at 22°C is intermediate in the Big and Small pool, while high in Dressing Room; at 37°C it is low in the small pool, while intermediate in the other two environments; fungal growth is intermediate for all environments.

MICROCLIMATE							IGCM/m³ (ACGIH, 1995)				
	Sampling point	TA (°C)	VA (m/s)	RH (%)	PMV	PPD (%)	Very low <500	Low <1000	Intermediate >1000	High >5000	Very high >10,000
Site I	Secretary	19.5	0	45.5	-0.3	7			√		
	Gymnasium	16.5	0.2	58.6	4.9	100		√			
	Dressing Room 1	20.5	0	50	-1.6	56			√		
	Dressing Room 2	17.8	0	57.3	-2.7	93				√	
	Dressing Room 3	15.9	0.01	69.6	-3	99		√			
	Store	22	0.02	50	0.6	13		√			
Site II	Small pool	27.6	0.03	52.7	1.3	39			√		
	Big pool	27.8	0.01	58	1.3	43		√			
	Dressing Room	26.4	0.03	59.8	1	26			√		

Table 2: Evaluation of microclimate and microbial pollution in Site I and Site II

Microbes	Range of value (CFU/m3)	Pollution degree (CEC, 1993)	Site I												Site II					
			Secretary		Gym		Dressing Room 1		Dressing Room 2		Dressing Room 3		Store		Big pool		Small pool		Dressing Room	
			37°C	22°C	37°C	22°C	37°C	22°C	37°C	22°C	37°C	22°C	37°C	22°C	37°C	22°C	37°C	22°C	37°C	22°C
Bacteria	<50	Very low										√		√			√			
	50 - 100	Low		√				√												
	101 – 500	Intermediate				√				√			√		√	√		√	√	
	500 – 2000	High	√		√						√									√
	>2000	Very High					√		√											
Fungi	< 25	Very low																		
	<100	Low		√		√		√		√		√		√						
	< 500	Intermediate														√		√		√
	< 2000	High																		
	> 2000	Very high																		

Table 3: Evaluation of microbial conditions in Site I and Site II

3.3. Water Analysis

Microbiological analysis confirmed the absence of any of the tested microorganisms. Table 4 shows the results of temperature values, the free and combined chlorine levelandpH. The temperature values were 27°C in both pools. The active free chlorine in Small pool, respectively for the first and second method, was 0.94 and 1 g/l; for the larger pool 1.23 and 1.40 mg/l. The combined chlorine in Small pool was 0.30 mg/l and in the Big pool 0.26 mg / l. The pH in the Small pool is 7.32 and 7.09 in the Big pool.

Indicators	Big pool		Small pool		Range of values
Temperature (°C)	27°C		27°C		24°C - 30°C
Free active chlorine (mg/l)	Orto-tolidine	DPD	Orto-tolidine	DPD	
	1,23	1,4	0,94	1	0,7-1,5 mg/l
Combined chlorine (mg/l)	0,26		0,3		≤ 0,4 mg/l
pH	7,32		7,09		6,5-7,5

Table 4: Results of temperature, free/combined chlorine and pH in the pools of Site II. Range of values (Italy, 2003).

3.4. Questionnaire

In Site I, hygiene-structural questionnaires were distributed to users. As for structural assessment (Figure 1a), 71% were satisfied respect quality of the plant, 70% were satisfied respect service, 64% respect safety. The percentages of non-satisfied are below 10% for both questions. The not very satisfied percentages are slightly higher, between 14% and 18%. Figure 1b shows the results regarding the cleaning assessment. The general perception of the plant status is considered satisfactory. The percentages of satisfied ranging from a minimum of 41% (room temperature and showers cleaning) to a maximum of 68% (dressing rooms cleaning); the highest percentage of very satisfied people has been found for dressing rooms cleaning (21%); the percentages of not very satisfied are around or below 30%; the unsatisfied are 0% respect temperature and a maximum of 18% respect cleaning.

Finally, the survey distributed in Site II, asked the issues should be improved about the suitability of the structure, safety, hygiene issues, dressing rooms, personal notes. For 45% of subjects the organization and structure of the dressing rooms should be improved; the 44% would not improve anything.

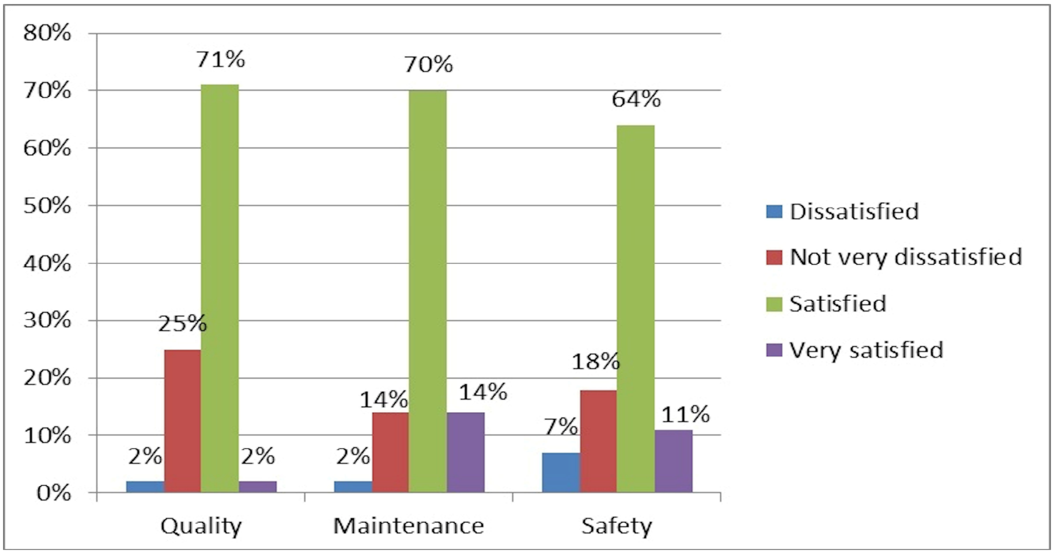

Figure 1a: Histogram on the structural section of the survey distributed in Site I.

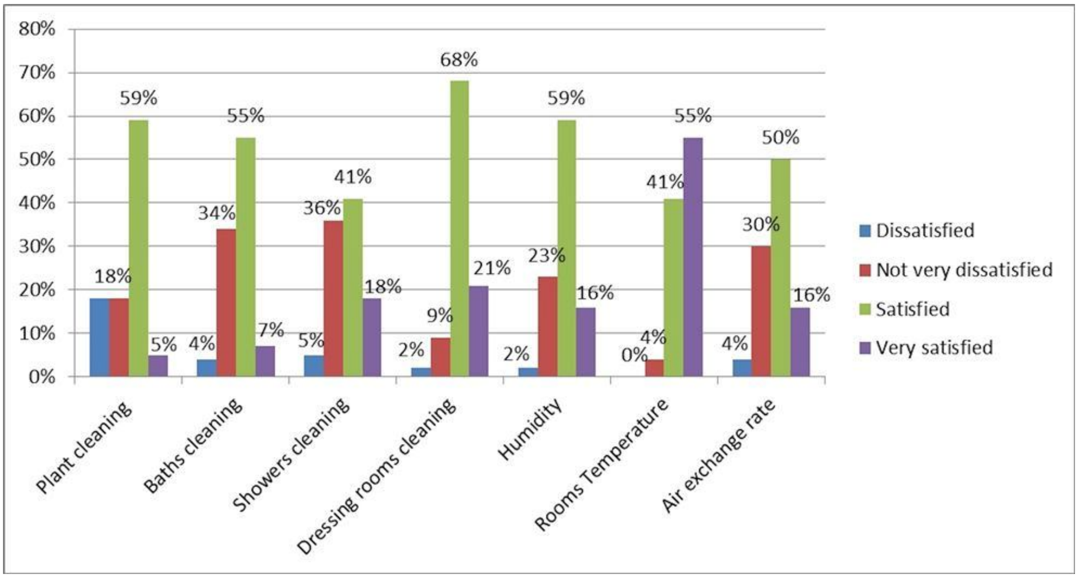

Figure 1b: Histogram on the hygiene section of the survey distributed in Site I.

4. Discussion

The quality and safety of sports facilities are key elements in the practice of physical activities, especially for those most vulnerable people, including elderly, children, and people with disabilities. The role that physical activity, adapted or not, is well known and established, not only in preventing diseases but also in the promotion of health and psycho-physical well-being of the person as well as in the care and rehabilitation (Romano Spica, 2015; Romano Spica, 2015). The quality of a structure dedicated to such activities is determined by multiple factors: topographical features, structural maintenance, the presence of pollutants, crowding of environments.

Air quality, however, can be affected by different substances resulting by the building materials, by interior materials (e.g. furniture) and by human activities. Some parameters are quantifiable with technical procedures (e.g. micro-climatic control units, air samplers, chemical test), others with custom tools, such as questionnaires (Alves, 2013). In a perspective of occupational prevention and health promotion, the approach presented in this study was aimed to integrate both objective parameters related to IAQ assessment and subjective perception of the environmental quality and safety. Previous studies investigated sport facilities focusing on single issues such as only questionnaires, or microclimate (Soares, 2015), personal information (Eime, 2013; Chen, 2013; Reimers, 2014), aptitude playing sport (Coledam, 2014; Laxer, 2013). Here we considered an integrated approach, to evaluate a possible multiple strategy to assess environmental quality in sport environments.

In the environments where sport was carried out and in the dressing room the PMV values were negative and the percentage of dissatisfied people (PPD) was equal or next to 100%. In Site II the microclimate is resulted slightly better, but non optimal. When comparing these results with the questionnaires distributed in Site I, we saw how the perception of the environmental quality can deviate considerably from the data obtained through the monitoring techniques. If room temperature and the humidity were evaluated satisfactory, by contrast, in the environments where was carried out sport activity and in the dressing room the temperature was considered cold and the relative humidity high.

Even for air exchange rate, there are discordant results: the mean air velocity recorded was around zero, while in the questionnaire it was evaluated satisfactory. The reason for this discrepancy may be sought in the fact that probably this survey presents questions in too subjective point of view and therefore should be reviewed. The hygiene perception was satisfactory and this is also confirmed by the microbial contamination index, which does not show worrisome values (in fact only the dressing room 2 of Site I shows high IGCM).

The questionnaires distributed in Site II show that generally most clients consider the hygiene and safety do not require improvements. It is not so regard dressing rooms: this is in line with our results, in fact relative humidity and temperature data were not acceptable. However, for both kinds of surveys, should be desirable to increase the number of the respondents. Our result are in line with another study: the cleanliness is considered the major weakness of this industry and it also has a significant impact on shaping customers' perception and classifying different levels of overall service quality. By contrast, accessibility is the main strength due to its high satisfaction level and low service quality gap (Liu, 2009).

The total fungal count results different in the two plants. The odds can be probably attributed to the different type of these facilities: a swimming environment, which is Site II, may further promote the fungi/mold growth. The microbiological investigations have confirmed the total mesophilic count (37°C) is the main contributor to contamination in Site I, while the psychrophilic count (22°C) is the main one in Site II. This situation is not in line with microclimate data, as in the Site I there were low temperatures but high relative humidity, in the second site there were high temperatures and humidity. The IAQ in both sites complies to the standards of non-industrial premises, but, is desirable for both plants the improvement of the ventilation system and air exchange, especially in the dressing areas, where the pollution, especially by bacteria, were intermediate/high. Finally, water quality data in the pools show accordance with Italian guidelines (Italy, 2003), both to microbiological indicators as to the physical and chemical requirements.

5. Conclusions

The characterization of a sports facility in terms of overall quality and safety is considered by several national and international regulations. It cannot be exhausted by using only a single type of monitoring technique.

A wider approach can take advantage from the combined determination of microclimatic parameters, microbiological air analysis, as well as evaluation of individual perceptions by customized *ad hoc* questionnaires (Dacarro, 2003).

Variables significantly affecting indoor microbiological contamination, such as structural features, microclimatic and seasonal variations, should be investigated within an integrated approach to get a global view (Valeriani, 2015). The data obtained in this study did not reveal critical situations for human health and safety, but evidenced a role for environmental quality. Surveillance on quality parameters can implement safety assurance with an impact on human health both for users and workers.

References

Adlakha, D., Hipp, A.J., Marx, C., Yang, L., Tabak, R., Dodson, E.A., Brownson, R.C. (2015). Home and Workplace Built Environment Supports for Physical Activity. *Am J Prev Med*, *48*, 104-107.

Alves, C.A., Calvo, A.I., Castro, A., Fraile, R., Evtyugina, M., Bate-Epey, E.F. (2013). Indoor Air Quality in Two University Sports Facilities. *Aerosol Air Qual Res*, *13*, 1723-1730.

American Conference of Governmental Industrial Hygienists (ACGIH). (1995). Industrial Ventilation: A Manual of Recommended Practice. Cincinnati, OH.

Australia. (1990). New South Wales Consolidated Acts. Swimming Pools Act 1990 n. 31.

Australia. (1992). New South Wales Consolidated Acts. Swimming Pools Act 1992 n. 49. [Online] available: http://www.austlii.edu.au/au/legis/nsw/consol_act/spa1992192/

Australia. (1997). Brown SK. Indoor air quality, State of the Environment Technical Paper Series (Atmosphere). Department of the Environment, Sport and Territories, Canberra. 1997.

Canada. (2004). Minister of Health. Miller JD, Gilbert NL, Dales RE. Fungal Contamination in Public Buildings: Health Effects and Investigation Methods. [Online] available: http://healthycanadians.gc.ca/index-eng.php

Canada. (2006). Règlementsur la qualité de l'eau des piscines et autresbassinsartificiels. Loisur la qualité de l'environnement. GazetteOfficielledu Québec, 13 décembre 2006, 138e année, n.50.

Carlisle, A.J., Sharp, N.C.C. (2001). Exercise and outdoor ambient air pollution. *Br J Sports Med*,*35*, 214-222.

CDC. (2003). Surveillance data from swimming pool inspections — Selected states and counties, United States, May–September 2002. *MMWR Morb Mortal Wkly Rep*, 52(22), 513-516.

Chen, T., Lee, J.S, Kawakubo, K., Watanabe, E., Mori, K., Kitaike, T., Akabayashi, A. (2013). Features of perceived neighborhood environment associated with daily walking time or habitual exercise: differences across gender, age, and employment status in a community–dwelling population of Japan. *Environ Health Prev Med*, *18*, 368-376.

China. (2002). Bai Z, Jia C, Zhu T, Zhang J. Proceedings: Indoor Air 2002: Indoor Air Quality Related Standards in China. [Online] available: https://www.irbnet.de/daten/iconda/CIB7659.pdf

China. (2006). Xiaojun M, Yiwen J, Yue C. "A new national design code for indoor air environment of sports buildings", *Facilities*, *24*, 458-464.

Coledam, D.H.C., Ferraiol, P.F., Pires, R.J., dos-Santos, J.W., de Oliveira, A.R. (2014). Factors associated with participation in sports and physical education among students from Londrina, Paraná State, Brazil. *Cad. SaúdePública*, *30*, 533-545.

Commission of the European Communities (CEC). (1993). Indoor air quality and its impact on man. Report No. 12. Biological particles in indoor environments. Luxembourg.

CONI. (2008). Directive CONI n. 1379 of 25/06/2008. “CONI regulations for sport facilities”.

CONI-FSN-DSA. (2014). The numbers of sport. Studies and Statistics Observers Center for Sport.

Council of Europe. (2006). Directive 2006/7/EC. “Management of the quality of bathing water”. [Online] available:
http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=URISERV%3Al28007

Dacarro, C., Picco, A.M., Grisoli, P., Rodolfi, M. (2003). Determination of aerial microbiological contamination in scholastic sports environments. *J. Appl. Microbiol*, *95*, 904-912.

Eime, R.M., Harvey, J.T., Craike, M.J., Symons, C.M., Payne, W.R. (2013). Family support and ease of access link socio-economic status and sports club membership in adolescent girls: a mediation study. *Int J BehavNutrPhys Act*, *10*, 50.

El-Salam, M.M.A. (2012). Assessment of water quality of some swimming pools: a case study in Alexandria Egypt,. *Environ Monit Assess*, *184*, 7395-7406.

European Commission. (2014). Special Eurobarometer 412. Sport and physical activity Report. [Online] Available: http://ec.europa.eu/health/nutrition_physical_activity/docs/ebs_412_en.pdf

Finland. (2010). Finnish Ministry of the Environment. Housing and Building Department. Indoor climate and ventilation of buildings regulations and guidelines 2010. Helsinki. [Online] available: http://www.ym.fi/enUS/search?n=25247&d=1&s=Indoor+climate+and+ventilation+of+buildings+regulations+and+guidelines+2010

France. (2011). AgenceNationale de Sécurité Sanitaire (ANSES). Air intérieur: valeurs guides. 2011. [Online] available: www.afsset.fr/index.php?pageid=829&parentid=424.

France. AfssetEvaluation des risquessanitairesliés aux piscinesPartie I: piscinesréglementées. SaisineAfsset «2006/11». Rapport final. [Online] available: https://www.anses.fr/fr/system/files/EAUX2007sa0409Ra.pdf

Gedikoglu, Y., Gedikoglu, G., Berkin, G., Ceyhan, T., Altinoz, M.A. (2012). Employing volcanic tuff minerals in interior architecture design to reduce microbial contaminants and airborne fungal carcinogens of indoor environments. *ToxicolInd Health*, 28, 708-719.

Germany. (1997). DIN-19643. Ausgabe:1997-04,Aufbereitung von Schwimm und Badebeckenwasser–Teil 1: AllgemeineAnforderungen. Beuth, Berlin. 1997.

Giampaoli, S., Valeriani, F., Romano Spica, V. (2012). Thermal water for recreational use: overview of international standards. *Ig SanitaPubbl*, *68*, 863-873.

Ireland. (2005). Safety, Health and Welfare at Work Act. Health and Safety Authority, 10 Hogan Place, Dublin 2. [Online] available: http://www.hsa.ie/eng/Legislation/Acts/Safety_Health_and_Welfare_at_Work/

Ireland. (2010). Swimming Pool Safety Guidelines. Irish Water Safety, ILAM and Swim Ireland. 2010. [Online] available: http://www.iws.ie/swimming/pool-safety.315.html

Italy. (2003). Agreement between the Minister of Health, the Regions and Autonomous Provinces of Trento and Bolzano: "Interregional discipline of swimming pools". In implementation of the State-Regions agreement and public administrations. 16 January 2003. [Online] available: http://www.bagnini.org/it/down/accordo_interregionale_piscine.pdf

Italy. (2005). Interior Ministry. Ministerial Decree 18/03/1996 (supplemented by Ministerial Decree of 06/06/2005). "Safety regulations for construction and operation of sports facilities".

Italy. (2007). ISTISAN report 7/11. Bonadonna L, Donati G. Swimming pools: sanitation and management aspects for the application of the new legislation. Istituto Superiore di Sanità, Roma 2007. [Online] available: http://www.iss.it/binary/aqua/cont/RappIstPiscine.1204716480.pdf

Italy. (2008). Legislative decree n. 81 of 09/04/2008 (Consolidated Law for health and safety at work). GazzettaUfficiale n. 101, of 30 April 2008.

Kirby, J., Levin, K.A., Inchley, J. (2013). Socio-environmental influences on physical activity among young people: a qualitative study. *Health Educ Res*, *28*, 954-969.

Laxer, R.E., Janssen, I. (2013). The proportion of youths' physical inactivity attributable to neighbourhood built environment features. *Int J Health Geogr*, *12*, 31.

Leemrijse, C.J., de Bakker, D.H., Ooms, L., Veenhof, C. (2015). Collaboration of general practitioners and exercise providers in promotion of physical activity a written survey among general practitioners. *BMC FamPract*, *16*, 96.

Liguori, G., Capelli, G., Carraro, E., Di Rosa, E., Fabiani, L., Leoni, E., Marensi, L., Napoli, C., Pasquarella, C., Romano Spica, V., Canossa, C., Dallolio, L., Di Onofrio, V., Gallè, F., Giampaoli, S., SItIWorking Group MovementSciences for Health (GMSH). (2014). A new checklist for swimming pools evaluation: a pilot study. *Microchemical Journal*, *112*, 181-185.

Liu, Y.D., Taylor, P., Shibli, S. (2009). Measuring customer service quality of English public sport facilities. *Int. J. of Sport Management and Marketing*, *6*, 229-252.

Moran, M., Van Cauwenberg, J., Hercky-Linnewiel, R., Cerin, E., Deforche, B., Plaut, P. (2014). Understanding the relationships between the physical environment and physical activity in older adults: a systematic review of qualitative studies. *Int J BehavNutrPhys Act*, *11*, 79.

Nathan, N., Wolfenden, L., Morgan, P.J., Bell, A.C., Barker, D., Wiggers, J. (2013). Validity of a self-report survey tool measuring the nutrition and physical activity environment of primary schools. *Int J BehavNutrPhys Act*, *10*, 75.

Netherlands. (2007). Inspectorate of the Netherlands Ministry of Housing, Spatial Planning and the Environment. RIVM report 609021044: Health-based guideline values for the indoor environment. 2007. [Online] available:
http://www.rivm.nl/bibliotheek/rapporten/609021044.pdf

Reimers, A.K., Wagner, M., Alvanides, S., Steinmayr, A., Reiner, M., Schmidt, S., Woll, A. (2014). Proximity to Sports Facilities and Sports Participation for Adolescents in Germany. *PLoS ONE*, *9*, 93059.

Revel, G.M., Artesano, M. (2014). Perception of the thermal environment in sport facilities through subjective approach. *Build Environ, 77*, 12-19.

Romano Spica, V., Giampaoli, S., Di Onofrio, V., Liguori, G. Safety of sports facilities and training of graduates in physical education. *Ann Ig*, *27*, 3-10.

Romano Spica, V., Macini, P., Fara, G.M., Giammanco, G., GSMS - Working Group on Movement Sciences for Health Italian Society of Hygiene Preventive Medicine and Public Health. (2015). Adapted Physical Activity for the Promotion of Health and the Prevention of Multifactorial Chronic Diseases: the Erice Charter. *Ann Ig* , *27(2)*, 406-414.

Russia. (1997). Baitkolov N, Musijchukb Y. Standards and Laws for Indoor Air Quality in Russia. *Indoor Built Environ*, *6*, 213-216.

Sani, S.M.T., Talebpour, M., Tojari, F., Jabbari, H. (2012). The relationships between the health status of athletic facilities and participation in physical exercises. *Eur J ExpBiol, 2*, 1240-1244.

Settimo, G. (2012). The Air Quality in Confined Environments: new national and community guidelines. *News of Italian Institute of Health (ISS)*, *25*, 5. [Online] available: http://www.iss.it/binary/iasa/cont/SETTIMO_notiziario_ISS.pdf

Soares, S., Fraga, S., Delgado, M.P.Q. J., Ramos, M.M.N. (2015). Influence of indoor hygrothermal conditions on human quality of life in social housing. *Journal of Public Health Research*, *4*, 589.

South Africa. (2002). Gansan J, Gqaleni N, Ehiri JE. Proceedings: Indoor Air 2002: Indoor Air Quality Legislation In South Africa. [Online] available: http://www.irbnet.de/daten/iconda/CIB7266.pdf

Sugiyama, T., Thomson, C.D. (2008). Associations between characteristics of neighbourhood open space and older people's walking. *Urban Forestry & Urban Greening*, *7*, 41-51.

UK. (2006). Management of Spa Pools: Controlling the Risk of Infection. Health Protection Agency. [Online] available: http://www.hse.gov.uk/legionnaires/spa-pools.htm

USA. (2012). National Institute for Occupational Safety and Health (NIOSH). Preventing Occupational Respiratory Disease from Exposures Caused by Dampness in Office Buildings, Schools, and Other Nonindustrial Buildings. [Online] available: http://www.cdc.gov/niosh/docs/2013-102/

Valeriani, F., Protano, C., Gianfranceschi, G., Santucci, S., Giampaoli, S., Vitali, M., Romano Spica, V., Mucci, N. (2015). Qualità dell'aria in ambienti confinati di vita e di lavoro: aspetti normativi e applicazioni al contesto sportivo e ricreativo. *L'igienemoderna*, *6*, 45-74.

World Health Organization (WHO). (2006). Guidelines for safe recreational water environments. Volume 2: Swimming pools and similar environments. Geneva: World Health Organization.

World Health Organization. (2010). WHO guidelines for indoor air quality: selected pollutants. 2010. [Online] available: http://www.who.int/indoorair/publications/9789289002134/en/