Disinfection

at High Level

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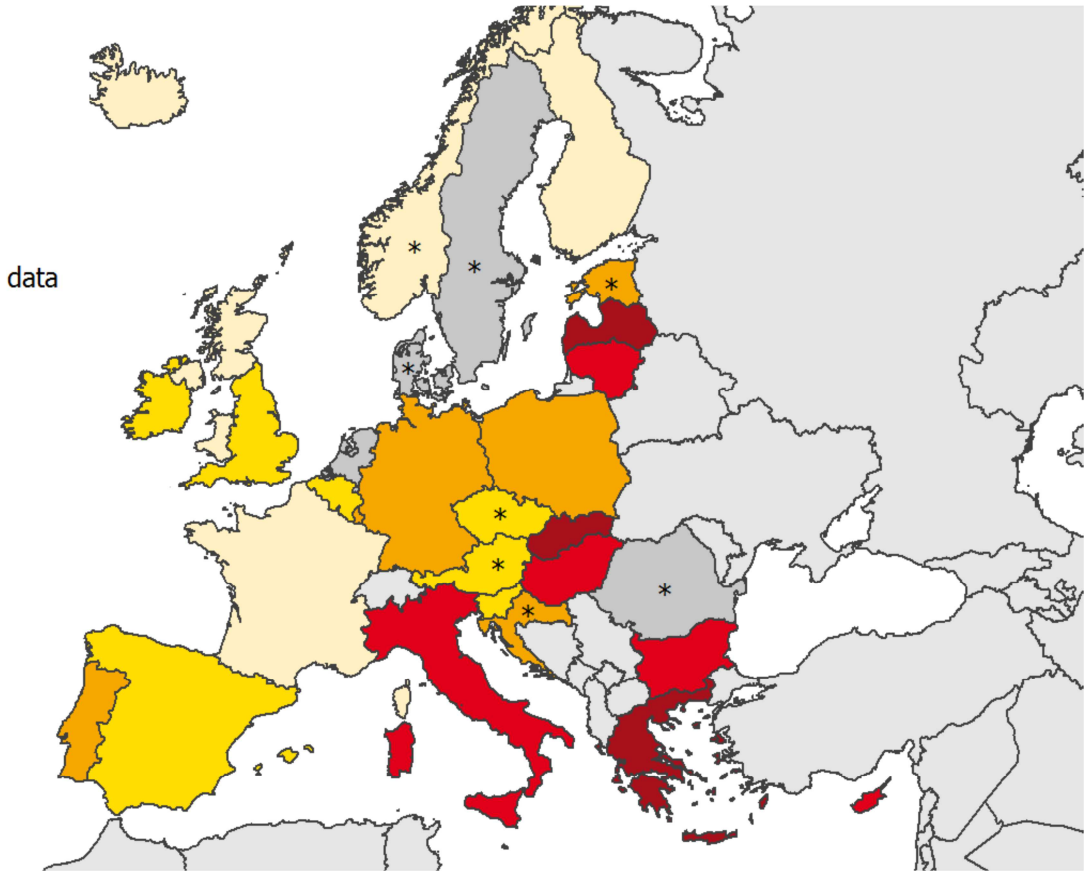
INTRODUCTION

After influenza pathologies about 4 million people, every year, contract an infectious disease, about the 25% is associated with the health care.

The direct average cost of a hospital infection was estimated to be about 10,000 € but adding other social costs, included the lacking productivity of the sick person, the costs are enormous, including the 8,000 deaths too.

The contagion mainly occurs by air, ingestion and contact; the 50% of Hospital Infections (HI) is especially caused by 3 bacterial species, but it is adding a large diffusion of infections by bacteria-producers of carbapenem (antibiotics-resistant).

Latest statistics of European Centre for Disease Prevention & Control (**ECDC**) assign to Italy, only for the HI, a percentage of contagion equal to 8% of admissions, on a lowest European average but more than numbers it is evident the following map:



The EU average is about 5%, with a minimum of 2% and a maximum of 10%, it seems certainly possible to regain efficiency in that sector bringing back to the statistical average, and it represents 300,000 cases and 3,000 deaths.

Adopt an adequate strategy, a higher action of awareness, as the Department of Health hopes with the latest circular 4968 of 2013, is an opportunity to cut down on costs of the National Health Service, to improve it and to raise the life quality of patients.

It is predictable that the adoption of extra measures, in addiction to the reduction of direct costs, can have further advantage on the staff's insurance costs (INAIL) and on the patients' insurance costs, that in Sicily they probably amount to 160 million Euros.

A cause of infection is certainly represented by the drinking water used in the facilities, and the most dreadful is **Legionella**.

The genus **Legionella** includes 61 species (subspecies included) and 70 serogroups, but not all are coupled with cases of human diseases.

Legionella pneumophila is the most frequently species identified in diagnosed cases and it is formed by 16 serogroups whereof **Legionella pneumophila** serogroup 1, responsible for the epidemic of Philadelphia; it is the cause of the 95% infections in Europe and 85% in the world.

The Legionellosis is generally distinguished in community, associated with travels and hospitals, and it is subject to the obligation of notification to ISS (DM 15/12/90), but there is an additional EU level of supervision ECDC; however annual reports about

infection's rate are underrated for lacking diagnosis and insufficient advisory.

In 2011 they were notified over 1,000 declared cases to the ISS, in reduction compared with the previous year, but it is not certain that these results are the fruit of greater attention to the diagnosis of **Legionellosis** and to an improvement of preventative and control activities; the proof will be verified during the next years if the decreasing trend will be confirmed.

Such great attention is certainly linked to the specific infection's virulence that it has a high index of mortality (about the 60%) and long period of convalescence.

Legionellosis is normally transmitted by air inhalation, aspiration or micro-aspiration of aerosol containing Legionella, or particles derived for drying.

A right program of control and prevention must have an engineering approach because **Legionella** lives in water but it infects by inhalation of aerosol in the air, infection's cases are been recorded near artistic fountains.

The Protocol for Control of Legionellosis Risk is divided into three sequential and correlated phases:

- **Evalutation of risk**: investigation that identifies the specificity of structure and system applied in it, they are connected with the real or potential presence of Legionella in the structures to the possibility to contract the infection;
- **Management of risk**: all interventions and procedures to remove definitively or to contain constantly the criticalities identified in the previous phase;
- **Communication of risk**: all actions aimed to inform, educate, sensitise the subjects interested in potential risk (manager of structure, control staff, customers, etc.)

SPREAD

Legionella is present in natural or artificial water environment where it finds best conditions to the proliferation with temperature from 5 to 55 °C, and pH between 5,5 and 8,1, in conditions of stagnation, presence of biofilm, incrustations and sediments.

The transmission is exclusively airbone via respiratory by inhalation wet air containing the bacteria.
The infection can naturally occur, but the risk is highest in interior or external environments where there is

aeresol of water, air conditioned places, and in other normal daily activities.

PREVENTION AND CONTROL

The state of the art about the systems of prevention and control is based on physic, chemical and mixed methods, all effective in short time, but not in middle term; the choice of the appropriate methodology is not the same for all, because it is strongly influences by the same water, by pre-treatments, by type of materials and conditions of system's use, by risk factor, etc.

The prevention of **Legionella**'s infections is essentially based:

- on the right planning and realization of technological systems which produce the water heating and/or the its nebulization (systems at risk). They are regarded as at risk, first of all, the hydro health systems, the systems of conditioning with air humidication by water, the systems of evaporative cooling tower or with evaporative condensers, the systems that distribute thermal waters, swimming pools and whirlpool baths;
- on the adoption of preventive measures (maintenance and, if necessary, disinfection) to

contrast the multiplication and the spread of Legionella in systems at risk.

As far as those measures do not guarantee that a system or its part are free from Legionella, they contribute to reduce the probability of a grave bacterial contamination.

It being understood that the respect of rules provided for existing rules and laws (UNI rules, etc.) to the building and maintenance of different types of systems, it refers to the main indications that they should be respected for an optimal control of contamination by **Legionella**.

GUIDELINES

The National Health Institute being subject to competing, in range of standing committee State-Regions, issued the guidelines for the prevention and the control of **Legionellosis**.

The European Union, still more recently, started up the l'**European Legionnaires' Disease Surveillance Network**, and it published, in range of EWGLI, extra guidelines complied with the various member States.

The **Sicilian Region**, with the Decree of 29 August 2012, identified **labs of regional reference** for the environmental and clinical supervision and the control of **Legionellosis**, and they are in an advanced phase of approval of guidelines.

Not only the guidelines want to give operative instruments to simplify the verification of cases and to identify the strategic choices about the preventive and control measures.

The guidelines issued by single regions, even if not all, make reference to that official document.

Chapter 7 of guidelines shows the minimum measures of prevention and control in the systems, whereas, chapter 8 reports the methods of prevention and control that they are shown below.

PHISICAL METHODS

1 **Thermal shock**, that is the increase of water temperature over 70 °C in all system and the maintenance in that condition for 3 days; time-limited efficacy, procedure to repeat periodically.

2 **Radiation**, that is the sublay of water to rays with a wavelength of 254 nm, (UV rays) that they act on bacteria DNA destroying it, but the efficacy is strongly influenced by various parameters, ant it is for the limited period only without residual effect.

3 A third method, not provided by the guidelines of **ISS**, is the **point of use**, that is the equipment of systems with filters, in particular end filters, able to stop particles less than 0,05 micron.

CHEMICAL METHODS

1 The chlorine is an oxidizing agent used with success for the hygienic and healthy control of drinking water. The inactivity and the suppression of L. pneumophila need a constant concentration of chlorine superior to 3 mg/l.

2 The **iper shock chlorination** has to take place at a temperature less than 30°C, with a single emission of water up to obtain concentrations of residual chlorine of 20 – 50 ml/l in all system, included distal points.

3 The **iper continuous chlorination** is obtained with the continuous addition of chlorine that it can be introduced, customarily, in the form of hypochlorite.

The residues of chlorine can vary, however the residue has to be included between 0,3 and 3 mg/l.

4 The use of **chlorine dioxide** is underway of experimentation, but there are not elements sufficiently validated for a safe and effective use. Indeed that procedure needs the presence of a generator which security conditions have to be guaranteed.

5 The treatment with **monocloramina**, used for over 20 years in USA, is a good disinfectant of drinking waters and for its greater persistence in water compared with chlorine and chlorine dioxide it assures an effective spread in dead branches and stagnant areas. In Italy it has recently patented in the treatment of sanitary hot water disinfection.

6 **Hydrogen Peroxide.** The treatment takes place through a stable and concentrated solution of hydrogen peroxide (peroxide) and silver, using the germicide action of each element and the developed synergy. The technique is quite recent as application and it necessitates extra experimental confirmations.

7 **Metal ions** are generated electrolytically and they have a concentration of 0,02 – 0,08 mg/l of Ag+, and of 0,2 – 0,8 mg/l of Cu+. The germicide effect persists for many weeks after the treatment.

8 **Bromine** is exclusivelly used in no potable industrial systems (cooling tower), although its efficacy is very limited.

9 **No oxidizing agents** (ketone, ethylene glycol, dithiocarbamates) generally have a small efficacy and a high level of toxicity.

10 **Ozone** has a quick efficacy, but it does not have a residual power.

11 **Metal Nanoparticles** in colloidal form are more stable and effective than ions, and their dosage is easy.

All water sanitizers based on chlorine, especially if they are used at the same time, form composites with the materials of systems and with the water impurity, in addiction the residual composites (chlorite - chloride - chlorate) have a lot of side effects and toxicity.

The efficacy of described methods is strongly conditional on the status of inner surface of water systems, on so-called incrustations formed by inorganic fouling and organic biofouling which through their stratification they facilitate the rooting and the nidation of microorganisms with an enormous proliferation of bacterial flora.

Therefore it is necessary an engineering approach to Disinfection at High Level with an adequate study of evaluation of risk and a plan of maintenance and descaling of the system, whose cost is certainly lower compared with the sum of damages that the chlorine produces, in addition to the energetic and heat saving that the exchange efficiency produces.

Each described treatment presents limitation in use and in temporal efficacy and, in the case of hospitals, spa and old people's home, it results strongly influenced by planning characteristics of the system under consideration.

That entails the need to choose the adequate strategy for the treatment of different parts in the system to disinfect.

The presence of biofilm and limestone deposits, the corrosion, the materials employed in the water supply network and the chemical and chemical-physical characteristics of water (for examples the pH, the temperature, the turbidity, the hardness and the organic dissolved substance) can interfere with the adopted method reducing the efficacy.

It is necessary the recourse to qualified person for the monitoring of chemical disinfectants' concentration and the bacterial analysis.

The chemical disinfection treatments described in this review could make sanitary hot water, temporarily or permanent, nonstandard to the quality requirements imposed by current regulations on water designed to human consumption.

Also any new techniques of disinfection will be compatible with the criterions of drinkableness of water established by law and they will be submitted to an evaluation by Department of Health.

NANOTECHNOLOGIES

The **Disinfection at High Level,** of water and environments, raises correlated problems that, for a right solution, they need an engineering approach and Qualifying Technologies, meant as “multidisciplinary technologies with high intensity of knowledge and associated with an elevated Research & Development, with cycles of rapid innovation, significant investment

costs and highly qualified jobs", as they are defined by EU.

Nanotechnologies are certainly a modern Science able to give new products and new methods for the Disinfection at High Level, obtaining results of quality and prestige with a considerable reduction of costs compared to traditional methods.

It is an antique knowledge that the silver has germicide, fungicide, viricidal and protozoicide property at broad-spectrum, it is approved by scientific community, but only recently the Researchers of **Rice University - Houston** have discovered the mechanisms.

About 5,000 years ago silver strips and coins were used to disinfect water, from about 2,000 years the eucharistic cups are in silver, but only in 1870 the modern science started to understand, and since 1950 the silver is used as disinfectant; during the war silver foils were used for soldiers' wounds.

With the arrival of synthesis' antimicrobial, the use of silver, natural product, took second place also because the costs of precious metal impeded the diffusion on market.

But the scientific research does not stop and the use of silver ions, generated electrolytically, starts again to dissemination the antimicrobial applications, that product has difficulty with use both for the its stability and the fluctuations of concentration, but also for the toxicity of supporting products in the electrolytic process.

During the last 20 years, with the arrival of nanotechnologies, nano silver particles (**AgNPs**) become the most employed germicide agents in the world; they are everywhere: in textile engineering, in cosmetics, in food, in detergents, in spray products, in water treatment; they are always used with the intent to stop the germs' spread.

A silver cube with a side of 1 millimeter weighs about 10 milligrams; the same weight is reached with over a trillion (1x10□□) of nano-particles of 10 nanometers of **AgNPs**.

10 mg liter of **AgNPs** are an effective colloid for the wide antibacterial, antiviral, antimycotic action that contain such quantity of bullets “caliber 10 nanometers”, millionths of millimeter, lethal for those microorganisms.

That is not enough, each bullet is not one, this is the discovery of **Rice University**. The researchers discovered

that those particles do not have any noteworthy antibacterial effect when, placed in anaerobic rooms, it prevents them to be oxidised in silver ions.

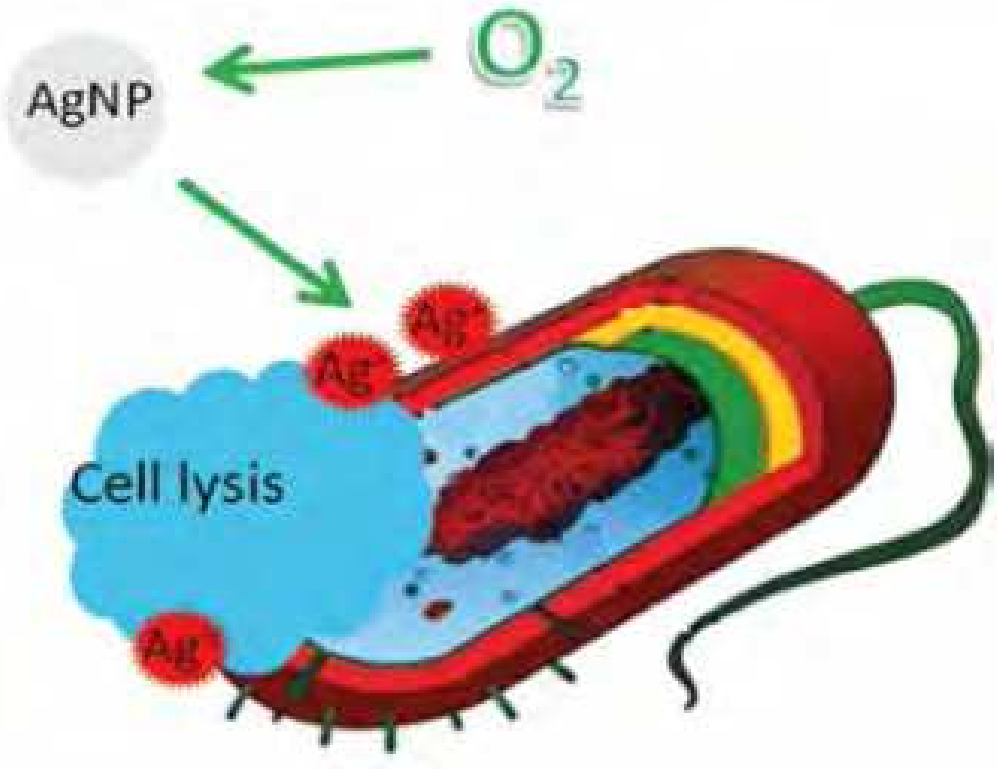
AgNPs in the absence of oxygen is an inert, stable and verifiable material, but it is a powerful vehicle to spread Ag+, the real germicide.

The researchers of Rice University confirmed that the biocidal action of **AgNPs** is in silver ions releasing from surface, it follows that each one of trillion of **AgNPs** has over 6,000 bullets; in one liter of colloid of 10 mg/l of **AgNPs** there is the quantity of lethal bullets for microorganisms that it is about 6 trilliard ($6x10^{21}$); with that entity no microorganisms stay alive after the bullets' rain.

In one drop of colloid there are more particles than stars in the Universe (about 200 billions). It is important to underline the action of **AgNPs**.

The silver ion acts on microorganisms stopping the metabolic and enzymatic system and altering DNA and the cell wall, in this way it causes the immediate death for cell lysis.

With that mechanism it is very difficult that the microorganisms find an adaptation making more effective the colloid **AgNPs**. In a drop of **SilverCloud®** there are billions of lethal particles for microorganisms called Ag+, they are natural and compatible with man.



EFFECTIVE DESCALING

NoName®

With the patent n° CT2011U000025, commercially called **NoName®**, it is developed a technique for the dosage of inert food gas that they work on the calcium/carbonic equilibrium able to exalt the function of universal water solvent and they produce an effective descaling eliminating the re-formation.

The mixture **NoName®**, completely ecofriendly, is composed of nitrogen, argon, carbon dioxide and blends of them; as it cleans up, the dosage is reduced, reducing also the disinfectants in use, and obtaining a low water hardness with a performance similar to systems of softening or osmosis, but with greatly lower costs.

NoName® method is fully tested in collaboration with the University of Catania and with the Regional lab of Reference for Legionellosis, with results, in vitro and in the field, that demonstrated the efficacy.

The descaling action, besides to favourably obtain the eradication, produced a best considerable energetic efficiency because the lower inner roughness of pipes improved the losses of load, consequently they reduced

the consumptions of electropumps, but they also produced a better heat exchange with a great increase of performance and lower consumptions of fuel for boilers.

Other noticed benefit is about the good look of taps and fittings because there are not calcareous rings, also in the kitchens, particularly in the dishwasher, it is noticed the high quality of washings and a reduction of detergents and sparkling aids.

The adoption of **NoName®** reduced the general costs in the famous hotel facilities where the test occurred for over 6 months, obtaining the appropriate documentation that attested the results.

NoName® process plans an accurate plant engineering study and the use of disinfectants compatible with the necessary chemical equilibrium, in order to optimise the performances.

DISINFECTION AT HIGH LEVEL

For the eradication of Legionella, the descaling produced by **NoName®** is an effective guarantee of result, but it is

necessary to complete the control and the prevention with the adoption of a continuous system of disinfection.

The current state of the art plan the adoption of systems based on chlorine/hypochlorite or chlorine dioxide; the last one has a rapid action and it mainly penetrates the biofilm, for this reason it is advisable in case of reclamation starting from diffused contamination.

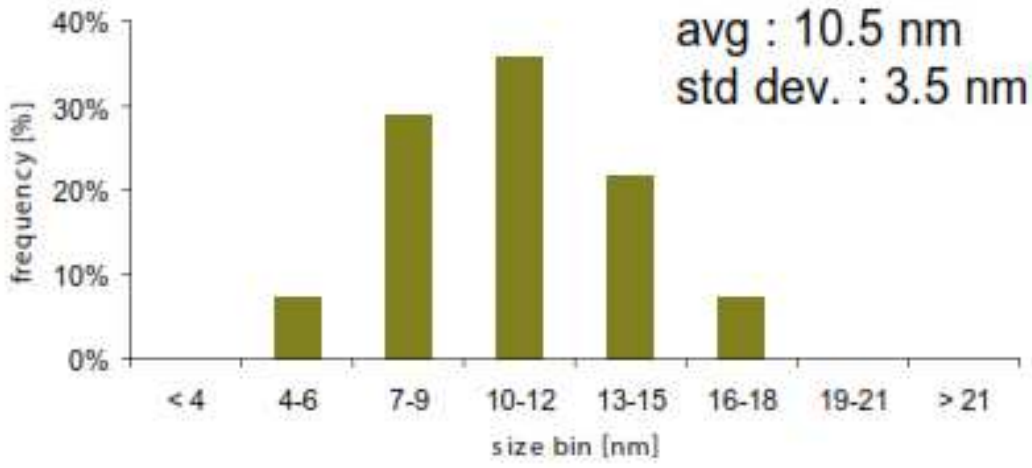
It takes cognizance that because of the common use of these disinfectants, they happened episodes of premature ageing of plastic pipes, but it noticed, in particular conditions, a considerable production of undesirable byproducts in drinking water.

Other benefit is the perfect compatibility with **NoName®**.

The joint process does not produce any considerable variation of water drinkableness' parameters, they do not originate unpleasant smell and taste, they are operative in alkaline pH, they are safe for health and respectful of materials.

SilverCloud®

SilverCloud® is the result of years of Research and Development in the field of Nanotechnologies that they permitted to develop a production process for the laser ablation of pure silver target, in demineralized water, of **AgNPs** from 10 – 12 nanometers, as characterized in the diagram.



SilverCloud® is a real silver colloid obtained with a physical process at very high frequency that it allowed to produce with a relative low cost but with a high level of purity and quality.

SilverCloud® is compatible with **NoName®**, maybe not as continuous disinfectant but, to make reclamation and periodic disinfections with complete guarantee of operation and security, while it is particularly indicated

for disinfections at high environmental level with micro portable nebulisers or with fixed systems at HiperMist.

The same group of companies, operating in the so-called District of **Etna Valley** that it has recently adhered to the **Distretto ad Alta Tecnologia Sicilia BioMedico (District of High Technology Sicily Biomedical)**, developed other complementary and synergetic techniques in the field of disinfection and treatment.

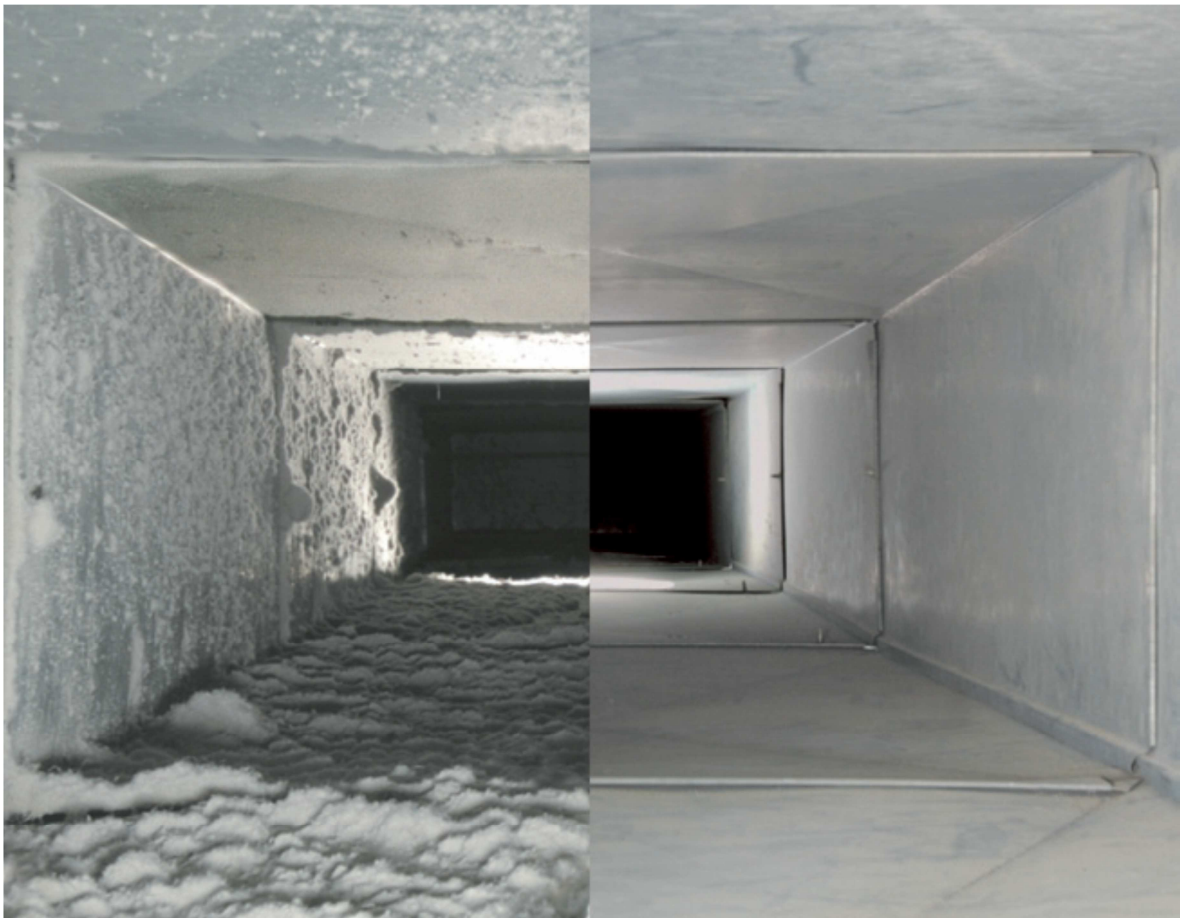
The product is already packed in dilutions at 10 ppm, but it can be also supplied in other concentrations and in other means, also in mix with other active particles like copper, gold, titanium, etc.

ENVIRONMENTAL DISINFECTION

The air quality that we breathe in close environments, is united to many factors that can contaminate it, in particular it is tied to the air, heating and conditioning systems, but also all materials and the surfaces of contact can influence.

The conditioning channels, although the maintenance is good and the filters are changed, get dirty and, as in the

water pipes, it creates a perfect environment for the proliferation of bacterial flora.



The *Syndrome of noxious environment* is a pathology approved by OMS, contra they are going to assert themselves the co-called *Green Building* born mainly for eco-save saving but they are going to expand in the concept of *humanization* of the environment, to obtain always greater comfort levels that in many cases they change into practical effects etching on the productivity

of workers, on the attraction of customers, more generally on the well-being of occupiers.

Latest studies demonstrated that the Environmental Wellbeing and the Quality of Air have a heavy influence on workers' performance because they are able to interact with senses activating particular emotions and mental states.

Procedures and guidelines are already available and many Associations, also international, qualify and certify the interventions of quality.

Turbine air sprayer are available for effective environmental disinfections and they mainly use disinfectants based on hydrogen peroxide in various concentrations.

Although effective, those interventions proposed at spot cannot be resolved for a long period, because the time of treatments and reconditioning of place is not short, and the activities can be direct without people.

Our group of companies creates fixed systems of micro nebulization with particular hydropneumatic nozzles able to supply HiperMist attested by 10 – 15 µm, with a programmable and easily repeatable flux, and counting on a low time concentration, with the use of specific products it is possible to maintain in continuous the system of disinfection, also in human presence.

ADVANTAGES

The working companies' group has the technological know-how able to face and resolve each kind of problems tied to disinfection at high level and to environmental and plant design reclamation, with an engineering approach but assisted by doctors, biologists and health experts, also for the close collaboration and for conventions with Public Authority and Systems Research that operate in range of **Distretto ad Alta Tecnologia Sicilia BioMedico (District of High Technology Sicily Biomedical)**, and of **District of Etna Valley**.

The technologies, that we propose, are the most innovative and they are the result of years of Research

and Development with the main target to obtain the best performances, but in order to reduction of costs, believing with that union the technologies spread over and, replying to Murphy's law, improving once again and reducing further the costs - this is our vision.

Our solutions are not standard and identical for all, but they are the result of an accurate evaluation of risk, to an analysis, also instrumental, of state of art, to preliminary design for a first economic evaluation, and only after the sharing and the approval of those phases, we can pass to a final design and to a focused economic proposal, also in conditions of achievement of results and success-fee, because we want to share the whole route with our customers.

For specific problems and particular environments, the same Group of companies is able to offer, keys in hand, structural and plant engineering solutions for an environmental control certified according to ISO 14644 (CleanRoom) and to EuDralex-GMP Vol 4 - Annex 1 (SterileRoom), up to the achievement of relative certifications and registrations.

We are on your hand from the first meeting to dedicate you our professional advice and our competence without

obligation, and searching together the best solutions with advantageous prices.

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