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2. PERSONAL PROTECTIVE MEASURES

2.1. Introduction

Collecting samples in an area potentially contaminated with CBRN agents is a challenging task. There are not only the hazardous materials to consider, but also other threats related to hostile activity or environmental hazards, such as IEDs or wild animals. These problems can also pose a significant risk to first responders and CBRN survey teams. Physically securing areas with armoured guards and antecedent activity of EOD patrol may reduce risk and allow personnel to focus on sampling mission. Nevertheless, there are unlimited scenarios for sampling which may happen during CBRN incident or terroristic attack, the common sense and general procedures constitute the base for successful missions. Depending on organizational approach or specific scenario, CBRN survey and sampling may rely on general NBC teams or specialized teams (chemical, radiological and biological). The biological agents with their intrinsic pathogenic and/or toxic properties, which include incubation period, communicability or unspecific symptoms and delayed diagnosis, are one of the greatest potential threats. Thus appropriate methods, practices and countermeasures have to be applied to reduce biological risk for first responders or sampling personnel. These include personal protective equipment, medical pre- and post-exposure prophylaxis as well as antiseptic and aseptic procedures during mission. Moreover training in special practices related with decontamination of PPE and equipment which leaving the zone, including enhanced general hygiene or even food consumption can't be neglected.

All measures which have positive influence on personal safety of potentially exposed duty officers, need to be undertaken. Considering specific nature of biological warfare agents they also protect non-exposed personnel, as well as their relatives and general public health. This chapter will focus on these aspects.

2.2. Biorisk assessment

Biological risk assessment and management is prerequisite action for successful biological sampling mission preparation. Even though there are unlimited numbers of CBRN scenarios, there are also defined lists of pathogens which can be used as

biological warfare agents, which have been discussed in previous chapters. Considering their properties as well as disease characteristic and availability of prophylaxis and treatment medications, the general or specific biological countermeasures may be planned and applied. Following aspects of biological warfare agents need to be considered during the biorisk assessment process:

- Survivability/stability in environment – bacteria are substantially more stable in the environment (bacterial spores can survive for many years in soils), while viruses are less stable, but non-enveloped viruses are more resistant than enveloped ones;
- Sensitivity to disinfection substances – the vegetative forms of bacteria and enveloped viruses are sensitive to majority of disinfectants. However spores are resistant to many disinfectants. Additionally, non-enveloped viruses, mycobacteria and fungi may be resistant to some types of chemicals;
- Probable dissemination method – the most likely pathway for the spread of many pathogens is an aerosol form, however there are some agents which can be used to contaminate water or food chain, or with using vectors;
- Infectious dose – the number of microorganisms required for development of an infection. This also depends on pathogen species or port of entry. For example, approximately one virus particle or 5–10 cells of *F. tularensis* (respiratory route) are sufficient for infection, whereas in case of *B. anthracis* from 8,000 to 50,000 endospores are required. In many cases the infectious dose is unknown or only rough estimated.

The other significant input for biorisk assessment is characteristic of diseases and available adequate prophylaxis and treatment medicines. These are:

- Incubation period – for different microorganisms is varied. It can last for several hours (*Escherichia coli*), a few days (*Influenza Virus*, *Yersinia pestis*, *Dengue virus*), and even a few months. This information may be valuable to predict quarantine and observation time;
- Mortality (number of fatal casualties related to number of cases) and prevalence. These factors determine a disease severity and directly allow to assess hazard related with agent, and potential consequences of exposure. It is also important to distinguish these factors among treated patients and non-treated patients as well as vaccinated and not vaccinated ones;
- Communicability of disease – there are direct and indirect ways of spreading of the infection. The direct way can be divided into: direct contact with sick person (e.g. contact with body fluids (*Ebola virus*, *Marburg virus*), droplets spreading during coughing and sneezing (*Influenza viruses*), sexual contact (*Zika virus*), vertical infection, from mother to child (through the placenta, during labour or breastfeeding). While the indirect contact includes: skin contact with contaminated material (*Bacillus anthracis*), faecal-oral route, consumption of contaminated water and food (*Escherichia coli*, *Vibrio cholerae*), aerosol route (pulmonary plague and tuberculosis) and infection by vectors e.g. direct contact with sick animal (e.g. bites or stings by infected animals (*Hantaviruses*) or insect

bites (*West Nile virus*, *Dengue virus*, TBE) or contact with waste containing microorganisms particles (*Hantaviruses*);

– Availability of vaccines and/or antibiotics – the presence of preventive measures and effective therapy to a particular pathogen significantly minimizes related biorisk. Basically, antimicrobial therapy is widely available, but when it comes to viruses, the specific treatment opportunities are very limited, rather supportive treatment is available. Moreover there might be some discrepancies of treatment measures in various countries depending on condition of medical service and wealth.

This information above will contribute to appropriate selection of disinfection substances, respiratory and personnel protection measures, needed vaccination or chemoprophylaxis measures. The characteristics of resulted disease will influence on medical procedures in case of exposed personnel or rescued casualties. The most challenging situation will occur in case of unknown agent. The worst case scenario has to be always foreseen in biorisk management. However, it might be presumed that in real situations (such as Anthrax letter incidents from year 2001), additional information about anticipated biological agents may be available. These may allow for more narrowed and specific biorisk assessment and management.

2.3. Medical measures

Medical prophylaxis and treatment medicines are very effective countermeasures in the long-lasting war of humanity against infectious diseases. Antibiotics and vaccines can also be very useful to protect personnel against biological warfare agents (Table 1). Thus, knowledge about available prophylaxis and medical measures is an essential point in mission preparation. Basing on results of biorisk assessment concerning particular agents and activities, vulnerable personnel has to be advised or obligated to undertake necessary medical measures to minimize the risk of infection. A special stockpile of these pharmaceuticals need to be prepared and stored in advance of any event. There might be requirements of prophylactic vaccination for duty officers in case of potential occupational exposure. There are for example legal requirements of vaccination in Poland for national defence and interior affairs ministries units. Vaccines are the main and the most effective medical prophylactic measures from the medical point of view. However, biological warfare agents and related diseases currently are not the top listed threats for public health. Thus, vaccines for them may be not easily available or there exist no vaccine on the market for some biological agents. On the other hand, widely available antibiotics, may be used for post-exposure prophylaxis or treatment of bacterial diseases. For viral biological warfare agents, special antiviral drugs may be applied, however often their efficacy are not fully tested or confirmed. Moreover, for some biological warfare agents specific immune antibodies (as well as antitoxins and antisera) can be applied against selected viruses, bacteria or toxins.

In case of directed or suspected exposure on biological warfare agent, especially in case of unvaccinated personnel – there is a need to implement special post-exposure prophylaxis procedures. The detailed action is heavily related to the characteristic of agent and disease (communicability, mode of transmission, infectivity, course of disease and availability of pharmaceuticals).

Table 1. List of diseases caused by potential biological warfare agents, with available vaccines and drugs

Disease	Causative agent	Vaccine	Drugs
Anthrax	<i>Bacillus anthracis</i>	available (purified antigen)	penicillin (except for inhalation anthrax in which the mortality remains high), ciprofloxacin, doxycycline, tetracyclines, erythromycin, chloramphenicol
Pneumonic plague	<i>Yersinia pestis</i>	available	streptomycin, tetracycline, chloramphenicol (for cases of plague meningitis), kanamycin, ROM therapy
Tularemia	<i>Francisella tularensis</i>	during the tests	streptomycin, ciprofloxacin, gentamycin, tobramycin, kanamycin, tetracyclines, chloramphenicol, aminoglycosides
Brucellosis	<i>Brucella suis</i>	not available for humans	tetracyclines, doxycycline with rifampicin, streptomycin, trimethoprim/ sulfamethoxazole (TMP/SMX)
Q-Fever	<i>Coxiella burnetii</i>	available	cotrimoxazole, rifampin, doxycycline, minocycline, tetracycline, clarithromycin, sparfloxacin, quinolones
Glanders	<i>Burkholderia mallei</i> , <i>Burkholderia pseudomallei</i>	not available	trimethoprim/sulfamethoxazole (TMP/SMX), ceftazidime, imipenem, doxycycline, minocycline, ciprofloxacin, gentamicin, ciprofloxacin sulphas, chloramphenicol, tetracycline
Smallpox	<i>Variola virus</i>	available	no specific treatment is available but cidofovir may be effective
Venezuelan Equine Encephalitis	Venezuelan Equine Encephalitis virus	available	no specific treatment is available

Disease	Causative agent	Vaccine	Drugs
Marburg Fever	<i>Marburg Fever virus</i>	not available	no specific treatment is available
Botulism	toxin of <i>Clostridium botulinum</i>	not available	antitoxin
Ricin-intoxication	Ricin	available	no specific treatment is available
SEB-intoxication	<i>Staphylococcal enterotoxin B</i>	not available	no specific treatment is available

Post-exposure measures may include: observation of casualty's health status, quarantine, application of antibiotics or antivirals or antibodies (antitoxin or antisera) as well as vaccination or revaccination (booster-doses) or combining these measures. Once symptoms of diseases developed, patients may be treated in isolation wards to prevent spread of disease in case of highly contagious and dangerous disease.

2.4. General protective equipment

Personal protective equipment (PPE) consists of specialized clothing or equipment used to prevent contact of personnel with hazardous CBRN materials. The PPE provides physical barriers that protect the potential entry ports for biological agents (hands, skin, eyes, nose, respiratory system and mouth) against contact with infectious agents, and potential infection or intoxication. This includes garments (suit, gowns, uniform), respiratory protection equipment, gloves, safety glasses, helmets, hoods, face shields, rubber boots and others. The PPE must be worn at all times during work with dangerous substances or sampling mission. Final selection of PPE, as a result of the risk assessment, has to base on mission-work environment description, analysis of potential hazardous agent, type of activity as well as individual capacities to fulfil the task in PPE. It is mandatory in European Union for employer to select and provide PPE, train personnel how to use it, as well as clean/decontaminate or dispose it. Legal requirements for PPE production and testing, including CE marking of PPE fall under European directive, which will be suppressed in near future with the directly applicable European regulation.

The main type of garment PPE for biological sampling mission are disposable or reusable coveralls (suits), which are more preferably used than other type of garment PPE, due to comfort of movement and readiness for decontamination

procedure. There are currently three categories of work-protective garment. Categories II and III are considered PPE, but for CBRN sampling missions the garment must belong to Category III (specialized cloths), which is applied to the life and health risks situations.

Current European standards for PPE, which can be used in biological sampling, relate to general demands for protective clothing but there are more specific document which cover biological safety. Since unknown event areas can also be burdened with other threats, other hazards like chemicals or radiation mustn't be neglected. Moreover decontamination procedure very often envisages disinfecting shower with harmful chemical substances. Various types of protective garments can be applied for situations, where chemical, biological, radiological or nuclear warfare hazards may be present (Table 2).

The European Standards specify the tests methods for materials intended to be used in the manufacturing of each type of protective clothing. General division into six types (depending on form of the threat: gas, particles liquid, vapours), relates to chemical safety but each type may be tested against biological agents according to EN 14126 which specify requirements and tests methods for protective clothing against infective agents (letter 'B' in suit code name).

Additional elements of protective suits may also be necessary to fully equip the personnel. These are for example gloves, which have to be both chemically and biologically resistant. On the other hand, they have to be thin enough to allow for precise work. Appropriate gloves must be worn for all procedures that may involve direct or accidental contact with blood, body fluids and other potentially infectious materials or infected animals. A special attention has to be paid for potential allergenic properties of material which has direct contact with skin. Many CBRN sampling teams work in double gloves regime (gloves are changed after changing location of sampling or collection of another sample), it is a reasonable approach compared to alternative option basing on frequent disinfection of gloved hand. Depending on suit type and presumed activity, many other items can also be useful: aprons, sleeves, rubber boots, safety glasses, face shields (visors) or other protective devices which must be worn when it is necessary to protect eyes and face from splashes or impacting objects.

Depending on the type and form of biological agent, exposure levels, type of work and risk of infection, consideration should be given to selection of the most adequate type of category III garment. General rule is that personnel which enters the unknown hot zone have the most advanced PPE (for example overpressure suits) whereas personnel engaged in warm zone (e.g. buddy decontamination, undoing or sample processing) wear lighter suits (e.g. with negative pressure respirators).

Table 2. Personal protective equipment – category III cloths types

Type	Pictogram		European standards
Type 1a		Full body protection against gaseous and airborne agents (respiratory device inside the suit).	EN 943-1 and tested by EN 464 :1994 if used by the emergency team, also EN 943-2 (code name: 1a-ET)
Type 1b		Full body protection against gaseous and airborne agents. (respiratory device outside the suit).	EN 943-1 and tested by EN 464 :1994 if used by the emergency team, also EN 943-2 (code name: 1b-ET)
Type 1c		Full body protection against gaseous and airborne agents. (breathing air provided by hose from outer stationary source).	EN 943-1 and tested by EN 464 :1994
Type 2		Full body protection against gaseous and airborne agents. (by positive pressure inside the suit).	EN 943-1, not tested against EN 464:1994
Type 3		Protect against jets of liquid.	EN 17491-3 EN 14605+A1 :2009
Type 4		Protect against sprayed liquid.	EN 17491-4 EN 14605+A1 :2009
Type 5		Protect against dust and airborne solid particles .	EN 13982-1:2004+A12010
Type 6		Limited protection against splashing of liquid.	EN 13034:2005+A1:2009
Type 1-6- B		Protect against biological agents.	EN 14126:2003

The other consideration related with thermal comfort of the personnel has to be included in planning. The majority of current biological suits are made from multilayer fabrics, which intend to provide both adequate resistance, barrier and improved vapour-permeability for comfortable usage. These fabrics

or synthetic materials are sophisticated laminates – multilayer materials made from polyurethane, polypropylene, polyethylene, polyester, cellulose, porous materials and breathable membranes. More resistant and thick fabric may result in decreased permeability and consequently decreased comfort of work in suit in hot or humid environments. This circumstance need to be overcome by shortening of the mission or application of cooling vests which allow to decrease temperature under the suit. The cooling effect may be obtained by thermoelectric effect (it needs electricity from portable battery), a phase change effect or ice packs. On the other hand in colder climate, the appropriate warm underwear have to be used to keep warmness under the suits.

Below four examples of the disposable Category III protective suits, which can be used in various type of missions and activities, are presented. The first suit (PROTEC® Plus) is rather light and may be used in presence of limited threats or warm zone activities (Fig. 1). It is made from breathable layer/microporous film (PE/PP). This suit is type 4B, 5B, 6 (protection against dust, particles, fibres and diffused substances) with protection against radioactive contaminating particles and biological hazardous substances. It is intended for work with lighter activities involving work with liquid and solid moderately hazardous substances (non-pressurized). It may be combined with any respiratory protection measure and other add-ons.



Figure 1. Example of a light Category III suit (type 4B, 5B, 6)

The second example suit (ProChem® II C/F – category III, type 3B, 4, 5 and 6 – Fig. 2) may be easily and tightly combined with negative pressure respirator (full-face facepiece) *via* butyl face shield seals as well as gloves (various types: butyl, nitrile, chloroprene) and rubber boots (or shoe covers with non-slip and antistatic sole). Entrance is from the back (a safer ‘solid front’ approach) and secured with two tabs closed with double-sided adhesive tape. It is much heavier (material: Tychem® F or C) compared to previous one (version C is lighter, though). It is intended for more intensive works including entering hot zone and direct sampling. It provides protection against inorganic and organic chemicals (only version F) in high concentration, dangerous biological hazards and contamination with particles, fibres and dust, radiation and protection against toxic warfare agents. It is resistant against even intensive personnel decontamination shower applied before leaving the hot zone.



Figure 2. Example of a heavier Category III suit (type 3B, 4, 5, 6)

The following example (ProChem® III F or C – category III type 3 and 5; Fig. 3) is interesting due to combining it with powered air purifying respirator (PAPR) as a respiratory protection measure. It is made from the same material (Tychem® F or C) and provides similar properties capacities as previous ones. It can also be supplemented with similar additional add-ons. The main

advantage of this type is application of the battery operated filtering device which eliminates the use of full-face facepiece respirator. Hence, it allows for prolonged (few hours) mission in more comfortable conditions – breathing is not restricted by negative pressure respirator. Impressive panoramic visor and size of suit's head part will improve observation field and it may help users who has problem with claustrophobia. Placing the PAPR device under the coverall (only the filtering units are outside) prevents it from being contaminated. The air from outside is filtered (at least P3 filters which may be combined filter against chemical/radiological agent) and clean air is blown over the head. This gives additional advantage for thermal / humidity comfort. Even though it was not tested against requirements of type 2 garment, it provides additional protection due to relative overpressure inside the garment, which prevents penetration of hazardous gases and particles. There are also similar types of suits, but combined with SCBA (self-contained breathing apparatus) instead of PAPR, which have their own advantages and disadvantages.



Figure 3. Example of a heavier Category III suit (type 3B, 4, 5, 6) with PAPR

The last example (ProChem® VI TK – category III, type 1a – Fig. 4) is the most advanced solution, providing maximum gaseous barrier for CBRN

hazards, even in higher concentration and under the pressure. The suit is made from heavy material Tychem® TK (triple dense as previous ones). It is equipped with breathing apparatus with compressed air and full-face facepiece as respiratory protection measure, which provide additional overpressure inside the suit. As a whole the suit and breathing apparatus provide protection against highly concentrated substances as well as in presence of toxic industrial materials, for which regular military or civilian chemical filter based negative respirators may be not sufficient. As the type 1a, the self-contained breathing apparatus is under the suit, which protects this expensive device against potential contamination. Panoramic visor of facepiece respirator and suit provide adequate observation field. It may be supplemented with sealed 'socks' or air-tight sealed rubber boots. The suit is combined with double glove work system, thinner gloves inside and thicker ones outside. It is tested additionally against standard EN 943-2 to meet special requirements for emergency rescue teams equipment.



Figure 4. Example of a heavy Category III (type 1a -ET), air-tight, SCBA-equipped suit for emergency teams

2.5. Respiratory safety

The main probable dissemination route for majority of biological warfare agents is aerosol. The primary threat: aerosolized bacteria, viruses or toxins are odourless and rather invisible. Once settled down, they contaminate affected area and equipment. The resulting biological fallout is source re-aerosolization and secondary threat. Thus protection respiratory tract is the indispensable part of biological PPE. There are two approaches for respiratory protection – isolation and filtration. The first method bases on supply of clean air (or oxygen) from an independent source. There are two types: stationary (air is supplied by air-hose) and autonomous (such as self-contained breathing apparatus SCBA). The second one, which bases on bottle of compressed air is preferably used in CBRN protection and by first responders. It provides the superior safety, which also includes other hazards (chemical gases, vapours, decreased level of oxygen) over filtration based methods. Moreover, they are positive pressure respirators (the pressure of clean air inside the facepiece is greater than outside) which is another safety advantage. However limited air amount in an autonomous high-pressure tank allows for missions which take less than one hour for the open circuit systems or four hours for the closed circuit system. The closed circuit system is more sophisticated and it is based on recirculation and recycling of exhaled gas. Thus the closed circuit SCBAs are much more expensive and complex in terms of routine maintenance, hence they are less widely used in CBRN protection.

The filtration based approach is more widely implemented in CBRN protection. It is simpler in use, cheaper in production and maintenance as well as suitable for long term storage. It consists of reusable facepiece (full-face facepiece or half-mask) and filtration unit (sometimes also adsorbing) or disposable filtering facepiece (FFP), where the whole facepiece functions as filter. The majority of filtration based masks are negative respirators (the pressure of clean air inside the facepiece during the inhalation is lower than outside). Full-face facepieces (e.g. regular military mask) are more favourable than half-masks, because they also offer face and eyes protection, however observation field and comfort of work is limited. Thus shape of facepiece has to be precisely fitted to the face, to reduce the risk of inhalation of unfiltered air (max. 0.05%). The single-use filtering facepieces (half masks) are being more popular nowadays. They are cheaper, lightweight and disposable, thus more comfortable (they do not need to be decontaminated after action). The disadvantages of this solution is related with their shape (half masks, which generate higher inward leakage) and difficulties to obtain adequate face seal.

The filtration based respiratory protection PPE may be enhanced with airflow supported by e.g. battery operated electric blower. This enhancement

leads to improved safety with applied mask, half mask as facepiece (*power assisted filtering devices*) and an implementation of positive pressured but loosely fitted facepieces like hoods or helmets (*powered filtering devices*). For example powered air purifying respirator (PAPR) connected with hood or overall suit (Fig. 4), offers better thermal comfort, observation field, longer work and comparable safety to other options (SCBA or negative pressure protective mask). This approach is being more popular in case of the absence of co-occurring radiological or heavy chemical contaminations.

Table 3. Filter classes under standards EN 143 and EN 149

Filter class EN 143:2000	Min. efficacy (%)	Other marks:	FFP class EN 149:2001	Minimum efficacy (%)	Inward leakage (%)	Occupational Exposure Limit
P1	80	NR – disposable R – reusable	FFP1	80	<22	4 x OEL
P2	94		FFP2	94	<8	9x OEL
P3	99.5	Colour: white	FFP3	99.5	<2	20 x OEL

Filtration efficacy of filtration units or filtration facepiece against solid and liquid aerosols falls into three classes in European Union (Table 3). Similar classifications exist in, for example, the USA (Table 4).

Table 4. Filtration efficacy based on 42 CFR Part 84 (US)

Filter class	Minimum efficacy (%)	Type of test
95	95	N – non-oil aerosols (e.g. N95, N99, N100) R – include oil aerosols with restrictions (e.g. R95, R99, R100) P – include oils aerosols (e.g. P95, P99, P100)
99	99	
100	99.97	

Filtering units may be combined with adsorbing materials and also provide protection against chemical agents. The respiratory protection equipment may be sensitive to inappropriate storage condition (temperature, humidity). Filter units are normally packed in hermetic bags, once they were opened, there may be some restrictions to reuse them. Respiratory protection PPE has maximum time of storage, which is marked on filtering unit or facepieces. It must never be used after the expiration date. For some *power assisted* or *powered* devices, a special attention has to be paid on batteries (in blower part) – they may need periodical recharging to sustain their lifetime and efficacy.

The prolonged usage of respiratory protection equipment may be related with serious sensorial stress (limited hearing, smell and observation field). That is why decision about enrolment of personnel to use the respiratory protection equipment and its careful selection has to include: type of activity, individual capacities and environmental conditions. Moreover individual capacities are related with age, sex, hair and shape of face (e.g. beard), psychological and neurological conditions (e.g. claustrophobia), health status (pregnancy, respiratory insufficiencies or chronic conditions). Since respiratory protection equipment usage need some fluency – the enrolled personnel has to undergo initial and refreshing trainings to sustain practical skills and readiness to unexpected events during the mission.

2.6. Personnel decontamination

Leaving the hot zone comprises significant risk related with transferring biological warfare agent out of contaminated zone. Thus all necessary actions should be undertaken to prevent uncontrolled release of agents into the 'clean' environment and to protect staff against potential infection or contamination by dangerous substances. Thus a comprehensive and credible decontamination is indispensable both after finishing work with dangerous substances and after work in the field where unidentified agents would have occurred. A whole process of decontamination should concern both equipment (including reusable elements and devices) and clothes (including boots, garment, gloves) of every person who may have been exposed to potential hazardous substances or agents.

Wastes remaining after sampling mission (such as used disposable garments, plasticware), and wastewater after decon procedure are hazardous wastes due to potential presence of harmful CBRN warfare agents or chemical disinfecting agents. Hence they are also subject to appropriate utilization processes like other hazardous wastes. The hazardous wastes management are regulated by series of general policies and specific regulations. Due to chemical and biological threats the waste from biological sampling mission may be included in group *H9 Infectious*, *H4 Irritant*, *H5 Harmful*, *H6 Toxic*. There are different methods and schemas which may be applied for infectious wastes utilization: autoclaving, chemical or microwave treatment, alkaline hydrolysis. Despite final burning in incinerator is not the cheapest method, it is the most effective one for reduction of waste volume and hazard.

On-site decontamination process often is undertaken in specially assigned warm (yellow) zone between hot zone (red) zone and cold (green) one. It can relate to the first responders' equipment, as well as to potentially exposed casualties (mass-decontamination corridors). The simplest but also the most effective approach is physical removal of dangerous agent by water solutions under field showers. Warmer water and some additives of detergents increase comfort and efficacy of process. This method is also environmentally friendly and has not

harmful side-effects to human health. On the other hand the increased risk may impose application of additional inactivating chemical agents. The combination of both methods (physical removal and chemicals) is more effective. There are several biocidal chemicals which can be used in solutions for decontamination procedures in the field condition. These are for example solutions based on: chlorhexidine, active chlorine (e.g. sodium hypochlorite), hydrogen peroxide, potassium monoperoxysulfate, peracetic acid or quaternary ammonium compounds (QAC). There are also several factors which have to be taken into account in planning effective decontamination and selection of appropriate biocide chemicals. The first one is its spectrum of activity, some disinfectants may not be equally active against all type of biological agents. There are some discrepancies especially in activity against bacterial spores, un-enveloped viruses, mycobacteria and fungi. Sometimes activity of disinfectant may be impaired by presence of organic substances. Hence the type and concentration of disinfectant or deactivator should be adjusted to the type of contaminant. Recently, solutions based on potassium monoperoxysulfate (and other ingredients) have been considered as disinfectants with the most broad spectrum. The side effects of disinfectants to human health (e.g. skin irritation, potential inhalation of vapours) and environment are also important factors in the selection process. It should be underlined that there is need to ensure appropriate contact between disinfection solution and contamination in proper time and temperature. Considering different properties of selected disinfectants and scenarios, there may be a need for additional action e.g. a pre-treatment shower (removing the organic substance, soaking which enhances contact), additional shower with neutral solution (removing the disinfectants) or application of PPE for protection against harmful activity of disinfecting substance. Thus, the knowledge about the components of the reagents used during work in the field and anticipated biological warfare agents may be helpful in selecting the adequate decontaminant which is simultaneously safe in use.

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