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THE COMPARATIVE STUDY OF EFFECTIVENESS OF DECONTAMINATION AGENTS ON DIFFERENT SURFACES IN THE NUCLEAR MEDICINE DEPARTMENT

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Abstract
This study addresses the effectiveness of using everyday cleaning agents for radioactive decontamination in the nuclear medicine department (PINUM). Eight cleaning agents (like water, soap solution, caustic soda, nitric acid, hydrochloric acid, citric acid, CCl_4 and EDTA) were analyzed for decontamination effectiveness for a wide range of surfaces (like marble, wood, cement, Aluminum, plastic, chip board and hard board). The results indicate that for a range of surfaces, the investigated commercially available cleaning agents had little or no benefit over soap, detergent and plain tap water when used as decontamination agent along with plastic and glass as best surfaces.

Keywords: Contamination, Decontamination, tap water and plastic, best combination, comparison with International results

INTRODUCTION

Radioactive decontamination can be relatively common occurrence in a nuclear medicine department when the equipment is contaminated with radioactivity; decontamination becomes necessary not only to restore the utility of the equipment but also to reduce the radiation exposure level of the employees as per requirement of the ALARA principle. Therefore radioactive decontamination needs to be recognized and removed as early as possible to restore full productivity of the department and maintain safe radiation practices. Ion-exchange resins have long been used for wastewater cleanup and radionuclide separation. The preparation of these resins often involves activation of the resin by altering the functional groups on the resin. For example in order to create a resin which will capture iodine, the resin in the chloride form must be stripped of chlorine and substituted with a

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functional group with lower electro negativity such as salicylate or citrate . The functional group attachment is reversible so by using high concentrations and/or larger volumes of these reactive groups, the chloride ion is forced to leave the resin due to the shear number of replacement ions competing for the site that the chlorine is bound to, the “mass effect”. It is postulated that cleanup of contaminated surfaces would be facilitated by the use of similar methods, treating the contaminated surface as an ion exchange resin and using competing ions to displace the contamination. Mixing specific ion exchange resins with the solution creates an alternate deposition site for the radionuclide on a particle, which can then be removed from the surface. The purpose of this study was to determine the best decontamination agent to use on different surfaces commonly used in nuclear medicine department. The research design examines the hypothesis that common decontamination agent such as soap and water are as effective as commonly used commercial decontamination agents, which are more costly, on plastic surfaces [1-5].

MATERIALS AND METHODS

Source preparation

Before the preparation of source following steps were taken

- Disposable gloves were worn
- A small amount of Iodine-131 activity was taken in 1cc syringe and injected into empty vial.
- The activity was measured using dose calibrator.
- Final source was prepared 260µci in 1ml

The source was prepared at the hot lab. Before measurements were done the entire source around the vicinity and the dose calibrator were removed and placed under lead shielding as these increased background radiations of the hot lab. We prepared a source of Iodine-131 (260µci) and taken Iodine-125 (225KBq in 45ml).

Plates Contamination

The source was taken to the isolation room where the experiments were to be carried out. The plates were first placed on the table covered with a polythene cover to avoid contamination on the surface of the table. It is important to carry out the experiment on a specific place because by specifying a place for experiment contamination of other items present near the contaminated plates can be controlled. Three measurements of background counts were taken before initializing contamination of the plates and an average was obtained.

- Indicate the contaminated area by means of appropriate radiation signs to restrict the access of the general public and hospital staff.
- Hands, feet, clothing and shoes were monitored using survey metres, where necessary radiation shielding material was used.
- Absorbed the contamination by absorbing sheet in order to control the spread of contamination.

The twelve plates were contaminated each time a decontamination agent was to be applied to decontaminate the surfaces .A small amount of contaminated (I-131 &I-125) was taken in an assay tubes, about 1ml, and the plates were contaminated by dropping 100µl, Iodine-125 and 50µl Iodine-131contaminant with the help of 50µl and

100µl, pipette respectively . Care was taken to avoid the spillage of the contaminant onto the nearby items. After contaminating the plate the surface was ready for decontamination [6-8].

Decontamination Procedure

Decontamination procedure consists of the following steps:

- Put on protective gloves and sleeves
- Other persons in the vicinity were informed of the contamination inside the isolation room
- Background counts were taken at the start of experiment.
- Before contamination procedure marked off the area by encircled it with a marker, in this way the contamination was contained to prevent any further spreading.
- One of us was monitoring the contamination using a survey meter while the other was decontaminating the plate.
- Using a radiation survey meter the counts for contamination were measured and noted down, took three counts before each decontamination stage.
- Started the decontamination by using a soft dry tissue by wiping the contaminated from the perimeter of the circle towards the center and measure the count rate thrice and average will be noted down.
- Now decontaminate the surface by using other agents, such as water, soap, detergent etc by dipping the cotton into the solutions of the agents and count rates were noted after applying each soak.
- After every soak the used tissues were disposed off in the radioactive waste container, which was later handed over to the radioactive waste management team of PINUM to be properly disposed off.
- For each stroke a new clean tissue was used.
- Three soaks for each decontamination agent were applied on the surfaces to get as much decontamination as possible.
- All readings were recorded in a table. The table was ready to be filled out before coming into the isolation room.
- As soon as all the readings were taken the plates were disposed off and handed over to radioactive management team for proper disposal.
- The protective gloves and sleeves were also put in the waste basket for disposal.
- All secondary calculations were done outside the isolation room to avoid further exposure to radiations.

Decontamination factor and removed percentage activity were calculated using the following mathematical expression [9, 10].

DF = Decontamination factor = Ci / C_f

Where C_i = initial surface activity, C_f = Final surface activity

Removed percentage activity = (1-(1/DF)) x 100

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RESULTS AND DISCUSSION

RESULTS

In radiological engineering the term contamination means the presence of undesirable radioactivity; undesirable either in the context of health hazards or for technical reason such as increased background, interference with tracer studies, clothing and skin of the workers may result from normal operations involving unsealed radioactive material, or as a result of breakdown of protective measures. Radioactive material which has been deposited on surfaces such as floors, tools, occurs at any nuclear facility or laboratory is largely composed of alpha, beta and gamma emitting activation products.

The removal of undesired activity is called decontamination. To remove or reduce the level of undesired activity, chemical and mechanical decontamination methods are applied in a safe manner. Alpha, beta and gamma radiation are odorless and colorless and leave no visible signs on the victims. Most of the radiation hazard comes from the radioactive dust attached to the victims. Nuclear contamination is very harmful than general contamination. So it is necessary to decontaminate that surface, article or person.

The main objective of this research work was to search out the surface, which can be decontaminated easily and best decontamination agents. In this research work different surfaces were use such as glass, Formica, chip board, hard board, aluminum, plastic, marble, wooden,, bricks, polished, ceramic and floor. These surfaces were contaminated by the spillage of Tc99-m and various decontamination materials were used to decontaminate these surfaces. The data and results obtained from these surfaces are as follows.

DISCUSSION

EFFECTIVENESS OF DRY SOAKS ON DIFFERENT SURFACES

Dry soak was applied at initial stage in order to control the spread of contamination and absorb maximum contamination. After applying the dry soak more than 95% of the activity was removed from Glass, Formica, Aluminium, Plastic, Ceramic, Polished, surfaces and 95% of the activity was removed from Marble and floor surfaces. Effect of dry soak on Chipboard, Bricks and Wooden surfaces was different. Removed percentage activities for these surfaces were 56%, 53%, 64%, and 84% respectively. The difference in results of dry soak for these surfaces was due to the porous and non- smoothness nature of these surfaces.

EFFECTIVENESS OF DECONTAMINATION AGENTS FOR DIFFERENT SURFACES

Water is a natural solvent, which is widely used for cleaning purposes. Its ability to dissolve different contamination makes it an ideal decontamination agent. Also its mild nature makes it more favorable for decontamination than any other decontamination agent. Water was the best decontamination agent for Glass surface. Maximum percentage of removed activity was 88% and its decontamination factor was 8.4. Water was not a good decontamination agent for Hard board surface and it removed only 10% of the activity due to the porous nature of hard board surface. Decontamination factor of water for hard board surface was 1.1.

Detergent was proved as the best decontamination agent for floor surface. It removed 81% activity from the

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floor surface and its decontamination factor was 5.5. But detergents were poor decontamination agent for Ceramic surface and removed only 14% activity. Decontamination factor for ceramic surface was 1.1. Detergents had the same effect for Marble and Wooden surfaces.

Liquid soap was found to be the best decontamination agent for Glass surface. Maximum percentage of removed activity was 93% and decontamination factor for Glass surface was 15.5. For floor surface minimum percentage of activity removed was 21%. And is decontamination factor was 1.2.

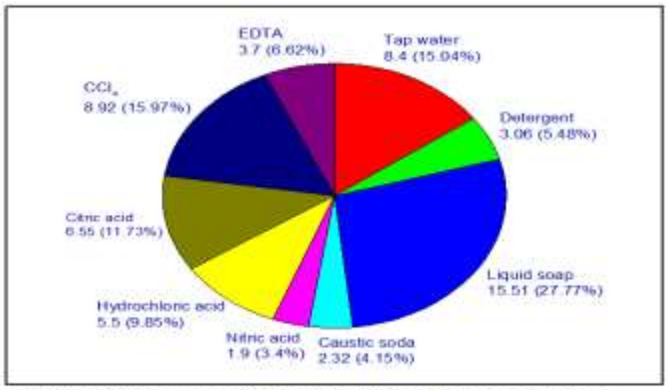

Figure 1: Comparison Chart for Glass surface

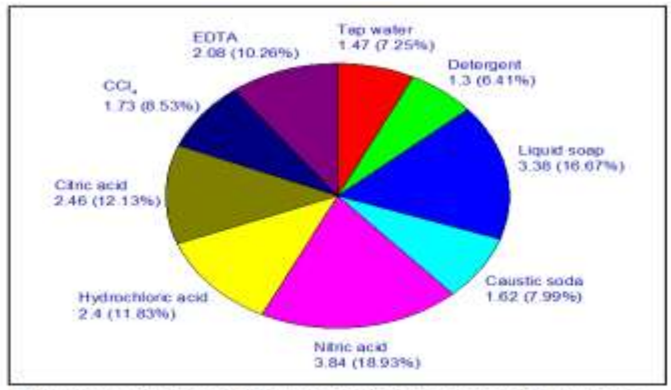

Figure 2: Comparison Chart for Formica surface

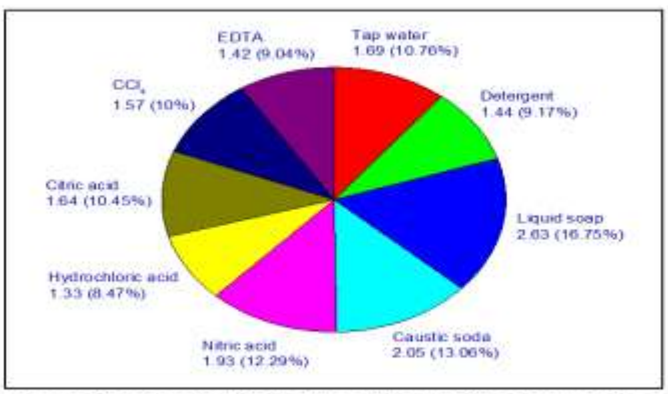

Figure 3: Comparison Chart for Chipboard surface

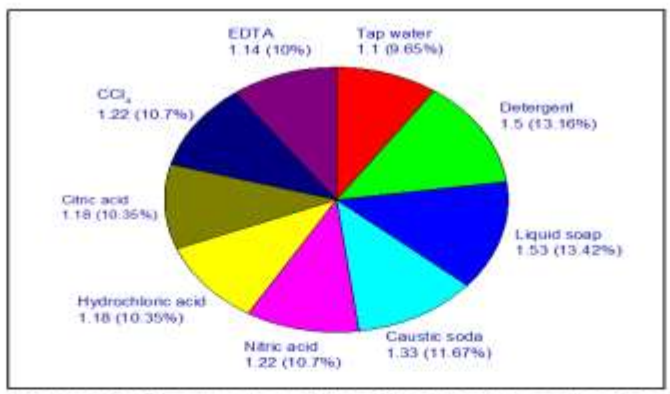

Figure 4: Comparison Chart for Hardboard surface

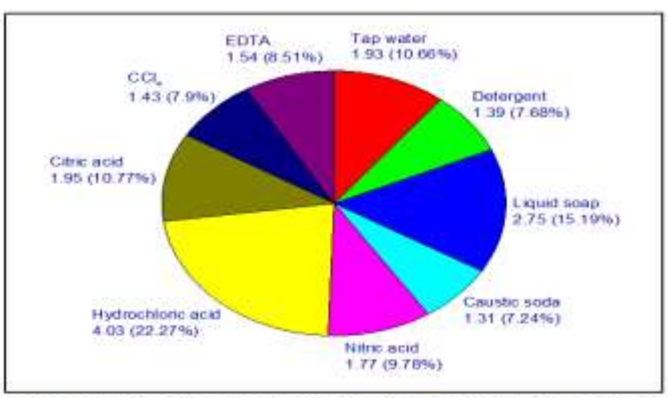

Figure 5: Comparison Chart for Aluminium surface

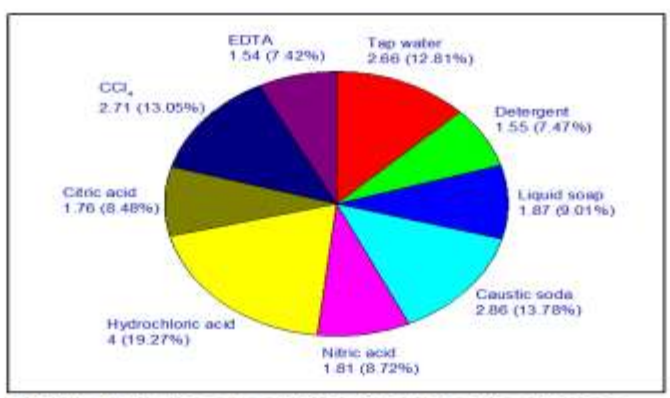

Figure 6: Comparison Chart for Plastic surface

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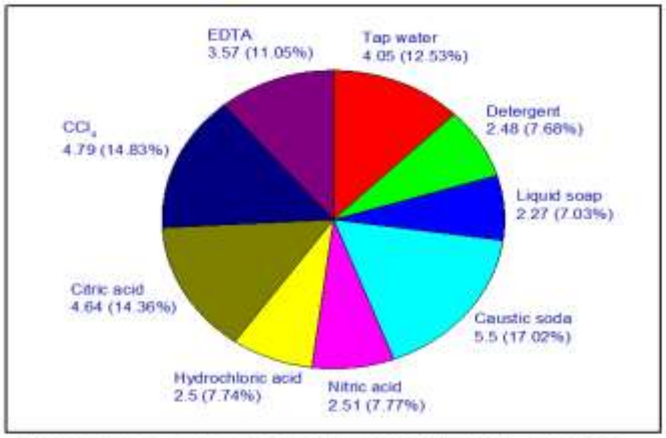

Figure 7: Comparison Chart for Marble surface

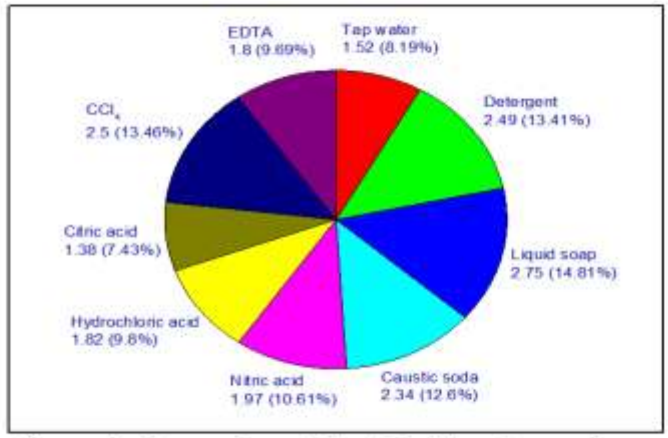

Figure 8: Comparison Chart for Wooden surface

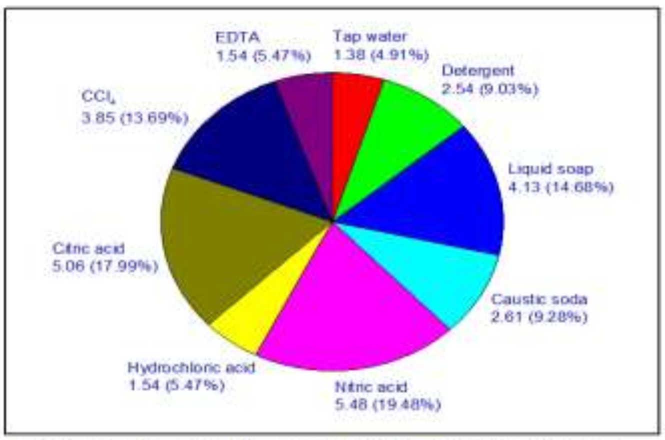

Figure 9: Comparison Chart for Bricks surface

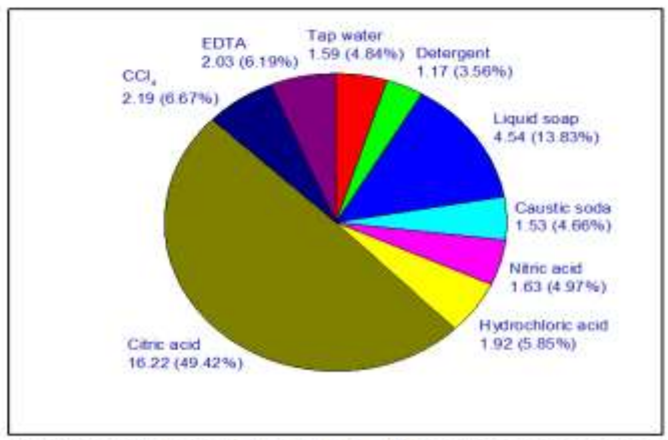

Figure 10: Comparison Chart for Ceramics surface

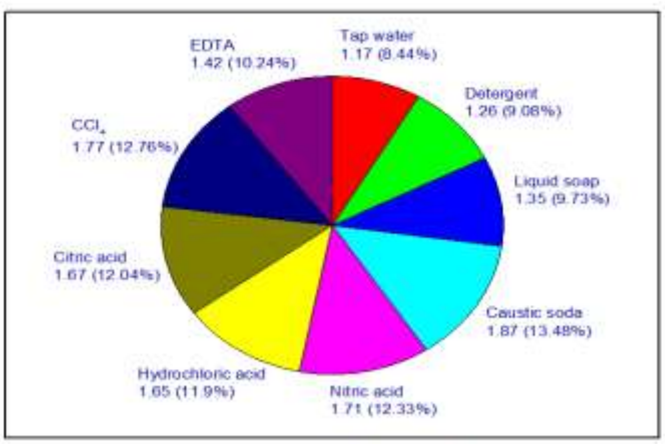

Figure 11: Comparison Chart for Polished surface

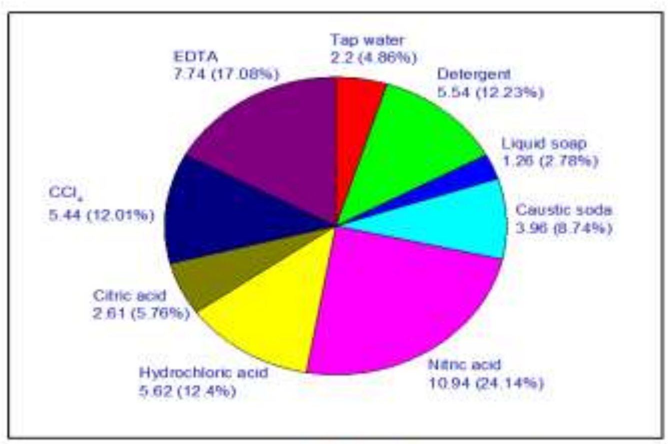

Figure 12: Comparison Chart for Floor surface

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Caustic soda was the best decontamination agent for Marble surface. Maximum percentage of removed activity for Marble surface. Maximum percentage of removed activity for Marble surface was 81% and its decontamination factor was 5.5. Minimum percentage of removed activity by using Caustic soda was obtained for Aluminum surface which was 23% and its decontamination factor was 1.31.

Nitric acid removed almost 90% of the spilled activity and its decontamination factor was 10.9. But Nitric acid was a poor decontamination agent for Hard board. It removed only 18% of the spilled activity and its decontamination factor was 1.2.

Maximum percentage of removed activity by hydrochloric acid was 82% and decontamination factor for Floor surface was 5.6. Minimum percentage of removed activity by using Hydrochloric acid was obtained for Hard board surface. It removed only 15% of the initial activity end its decontamination factor was1.1. Hydrochloric acid had the same effect for Aluminum and Plastic surfaces.

Citric acid was best decontamination agent for Ceramic surface. Maximum percentage off removed activity for Ceramic surface was 93% and its decontamination factor was 6.2. But Citric acid was poor decontamination agent for Hard board surface. Percentage of removed activity for Hard board surface was 15% And decontamination factor for this surface was 1.1.

Carbon tetrachloride was the best decontamination agent for Glass surface. Percentage of removed activity for this surface was 88% and its decontamination factor was 8.9. But it as not good decontamination agent for Hard board surface. It removed only 18% of the spilled activity and decontamination factor for this surface was 12.

Maximum percentage of removed activity by using EDTA was obtained for Floor surface hat was 87% and decontamination agent for this surface was 7.77. EDTA was poor decontamination agent for Hard bard surface and minimum percentage of removed activity for this surface was only 12% while the decontamination factor for Hard board surface was 1.1. EDTA had the same effect for Aluminum, Plastic and Bricks surfaces. Number of counts decreased as number of soaks increased.(Graph 1 to 12)

For Glass surface effectiveness of Water, Citric acid, and CC4 has the toxic nature therefore water was preferred as best decontamination agent for glass surface. Graph 1 show that decontamination factor for liquid soap was maximum. Another advantage to use water for Glass surface is its availability and cost effectiveness.

Graph 12 shows that for Floor surface Nitric acid was best DTA, HCL and Detergents were also good decontamination agents for Floor surface. But HCL and Nitic acid are strong acids and can damage the surfaces and therefore they were avoided.

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Smilar type of study was performed in Florida by B.Schmidt et al. They reported results for decontamination of Concrete surface using Ion wash, Radiiac wash, Water and Bind- it as decontamination agents. Decontamination factor for these agents were 1.1,1,1 and 1 respectively. Decontamination factor for water in our study is greater (2.2) than that in the published results. Reason is that the spilled activity in our study was lower that is approximately 5 times lesser then the repoted data while the spilled activity in the published results is 14.7 MBq [12].

For Marble surface CCL_4 and water were also good decontamination agents a well as Caustic soda. CCL_4 has the toxic nature and Caustic soda or sodium hydroxide is a strong base and it is chemically reacting with fats. Therefore water as preferred as the best decontamination agent for Marble surface due to the mild nature ad cost effectiveness. Similar type of study was performed in Florida by H.Kuperus et al. They reported results for decontamination of Tiles using Ion wash, Radiac wash, Water and Bind- It as decontamination agents. Decontamination factor for Water in our study is greater (4.0) because the spilled activity in our study was lower that is approximately 3 Mq while the spilled activity in the published results is 14.3 MBq [12].

For Formica surface Nitric acid, Citric acid and Liquid soap were best decontamination agents. But Liquid soap was preferred due to its mild nature. Graph 2. Shows that of Ntric acid is maximum. Liquid soap was preferred as best decontamination agent instead of Caustic soda, Nitric acid and Detergent for chipboard and hardboard surfaces. (Graph 3 and 4). Water was best decontamination agent for Marble and Plastic surfaces as compared to Caustic soda, and HCL, another advantage to use water was its availability and cost effectiveness. (Graph 6 and 7). HCL was best decontamination agent for Aluminum surface but it can damage the surfaces therefore Liquid soap was preferred due to its mild nature. (Graph 5). Liquid soap was preferred as best decontamination agent for Wooden, Bricks and Ceramic surfaces as compared to CCL_4 and Nitric acid (Graph 8, 9 and 12) [9-15].

CONCLUSIONS

Following are the concluding remarks from the above discussion to carry out initiate an emergency plan for decontamination purpose in Nuclear Medicine department. A decontamination kit should be available in all critical sites. From present research work it is suggested that to include the EDTA and liquid soap along with moist towels in decontamination kit. For a complete and maximum removal of activity first of all absorbent papers and cotton should be used as a dry soak in order to avoided the spread of contamination for surface safety point of view. Liquid soap and Water are ideal decontamination agents for most of the surfaces.

We conclude following characteristics recommended for an ideal surface.

1. Smooth and non porous (minimum of adsorption area and penetration).
2. Nonionic (minimum exchange)
3. Resistant to corrosion by acids , alkaline ,organic solvents,
4. Resist to heat

For decontaminating plastic surfaces dry soaking is the best way to decontaminate the plastic surfaces. Because almost 99% of the contamination can be removed from the plastic surfaces using dry soaking. But care should be taken to avoid the spread of decontamination during decontaminating.

The technical reasons of selecting Plastic as the best surface are as follows:

1. Plastic is an oil- based polishing compound.
2. This compound contains a fine, uniformly-dispersed abrasive to avoid scratching and lubricant to help prevent heat buildup and melting of the surface.
3. This compound includes at least one petroleum distillate lubricant(preferably a blend of lubricants), mineral spirits, abrasive paste, and water.
4. This compound includes by weight approximately 25 to 80 parts lubricant, 1 to 12 parts mineral spirits, 50 to 155 parts abrasive paste, and 15 to 60 parts water. The proportions of the ingredients are varied in accordance with the particular application. Thicker formulations containing relatively more abrasive paste are effective polishers, while thinner formulations containing relatively more liquid are useful as cleaners.
5. This compound remains in workable condition on the polishing pad and the wcrk piece, so the operator does not need to stop to clean dried material off the workpiece or polishing equipment, as with water-based polishes.
6. When polishing is complete, the residue is easily removed with a clean, lint-free cloth, leaving a smooth, clear surface without observable scratches.
7. *A*n important feature of the present invention is the petroleum distillate lubricant. This lubricant facilitates uniform dispersion of the abrasive material, keeps the polishing compound workable, and ensures effective, continuous lubrication of the surface during polishing. Preferably, a blend of lubricants of t different weights is used, however a single lubricant having the desired lubricating properties may be used if convenient.
8. Another feature of the present invention is the mineral spirits, which facilitates mixing and dispersion of the other ingredients. The mineral spirits penetrates to the surface of the work piece, assuring complete wetting of the surface so the polishing compound readily spreads into small surface scratches and blemishes.
9. It also dissolves surface grease and removes any dirt on the surface at the start of polishing.
10. Still another feature of the present invention is the abrasive paste. The paste preferably contains about 30 wt% to 60 wt% abrasive material in a suitable binder.
11. Abrasives usable in accordance with the present invention include crystalline silica (quartz), alumina, and the oxides of iron, chromium, tin, titanium, and the rare earths. Binders may include a blend of mineral spirits and petroleum distillates as well as other substances such as hydrogenated animal fat, tallow fats and triglycerides. Coloring and fragrance agents may also be present if convenient in an application of the present compound intended for consumer use.
12. The lubricant and mineral spirits dissolve and disperse the abrasive paste to produce a smooth, uniformly blended mixture. Because the abrasive particles are uniformly dispersed throughout the compound, scratching due to sealing or clumping is eliminated.

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13. A further feature of the present invention is the combination of ingredients. The compound contains a fine-grained abrasive to avoid scratching, a lubricant (preferably a blend of lubricants of different weights) to help prevent heat buildup and melting of the surface, mineral spirits to facilitate mixing and dispersion of the other ingredients, and water.
14. All the ingredients are readily available and inexpensive, and each contributes without countering or buffering the effect of the others. The combination of ingredients achieves a smooth, clear finish when used to polish a plastic surface.
15. Preferably, the polishing compound includes by weight approximately 37 to 42 parts lubricant, up to 8 parts mineral spirits, 95 to 110 parts abrasive paste, and 50 to 55 parts water, Thus, one weight unit of the compound includes 18 wt% to 20 wt% petroleum distillate lubricants, up to 4.wt% mineral spirits, about 50 wt% abrasive paste, and about 25 wt% water. A compound with these proportions of ingredients has approximately the consistency of heavy cream.
16. These proportions give a stable, easy-to-use compound for polishing plastic surfaces. If convenient, the mineral spirits may be supplied in combination with a lubricant or lubricants, such as by providing lubricant/mineral spirits combination and a lubricant of different weight such as machine oil or spindle oil.
17. When so formulated, one unit of the polishing compound includes by volume 2 to 6 parts lubricant/mineral spirits combination, 1 to 3 parts machine oil, 2 to 6 parts abrasive paste, and 2 to 7 parts water. Preferably, the compound includes by volume approximately 4 parts lubricant/mineral spirits, 1 part machine oil,4 parts abrasive paste, and 6 parts water.

If desired, other ingredients such as corrosion inhibitors and color and fragrance agents may be added without departing from the spirit of the present invention. Lubricant/mineral spirits combinations usable in accordance with the present invention include those sold under the trademarks WD-40 [16-23].
Radioactive contamination in nuclear medicine department can be cleaned quickly and effectively using soap, detergent and plain tap water. Commercially available decontaminating agents such as Radiacwash offer no observed benefits over any of the decontamination agents used in this study. Thirty seconds of cleaning with said agents will remove more than 85% contamination from many commonly used surfaces such as plastic and glass in nuclear medicine department.

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