Hospital waste disposal a health risk

Only two of three of an estimated 145 public hospital incinerators in Victoria perform well enough to ensure adequate breakdown of medical waste, research by four post-graduate students in Environmental Science has found.

In some cases, incomplete destruction of such wastes could lead to the emission of toxic and cancer-causing pollutants from incinerators.

The study was concerned particularly with the fate of cytotoxic drugs, substances lethal to cells which are being used increasingly in the treatment of cancer and other diseases.

The students set out to measure the minimum combination of temperature and time inside an incinerator needed to breakdown cytotoxic drugs as part of a much wider project looking at all aspects of management of cytotoxic wastes.

Their study suggests that the recently proclaimed Victorian Environment Protection Authority (EPA) standard of 1100 degrees Celsius for one second is adequate to break down medical waste provided sufficient oxygen is present.

At lower temperatures and oxygen levels, however, not only do the more stable chemicals persist, but the study found there was potential for new and dangerous compounds to form.

More than 95 per cent of public hospital incinerators in Victoria do not meet the standard, either because of their design or the way they are operated.

The students undertook the research project to fulfil part of the requirements for a Master of Environmental Science degree. The course demands that such research work be of direct application.

Their work was sponsored by the Victorian EPA, which contributed equipment, expertise and $10,000. The Health Department of Victoria granted them $20,000 and the largest local manufacturer of hospital incinerators, Warren Engineering, agreed to build a $50,000 incinerator especially for the research.

The students' report recommends more careful labelling and handling of hospital waste, training of waste disposal personnel, and proper supervision, siting, design, fitting and operation of incinerators.

It also suggests that for the disposal of cytotoxic waste, hospitals might find the construction of larger, more efficient, pooled facilities away from clinical areas safer and more economical.

Already, on the basis of the study, Warren Engineering has decided to modify the operation of a commercial cytotoxic waste disposal centre in Dandenong, 30 km southeast of Melbourne. And New South Wales and Victorian regulatory authorities now are seriously considering the report's implications.

The idea for the project originally came from applied scientist Paul Clarey, who works in the Hazardous Wastes section of the EPA. After conducting a feasibility study with fellow student and organic chemist, Nichola Porter he managed to interest two other students in the work — microbiologist Margaret Dooley and behavioral scientist Anne Tacey, who was concerned with the occupational-health aspects within hospitals.

Continued Back Page

- An incinerator loaded with cytotoxic waste. Note the special markings on the boxes.

INSIDE

- Diet slows ageing 2
- Gene repair 3
- Mite is right 4, 5
- Playbox at Alex 6
- Update 7
Diet can slow old age, new theory proposes

The onset of old age may be slowed or greatly modified using simple dietary supplements if a new theory of ageing proposed by biochemists from Monash and Nagoya universities proves to be correct.

The new theory, recently published in a paper in the influential British medical journal, *The Lancet*, also provides support for the controversial practice of using large doses of Vitamin C as preventive medicine.

In the *Lancet* paper Professor Anthony Linnane and Associate Professor Sangkot Marzuki of the Monash Centre for Molecular Biology and Medicine and two Japanese colleagues suggest that ageing and several degenerative diseases are caused at least in part by a lifelong build up of mutations in the genetic material of the mitochondria, the cell's energy production centre.

The mitochondrial genetic material is responsible for the construction of 13 enzymes (catalysts) critical to the body's system of energy storage and release. These enzymes are linked together into an energy production line, where the product of one reaction becomes a necessary ingredient of the next.

Hence a defect in any one of the enzymes can render the line, and the mitochondrion containing it, inactive. The researchers argue that over time, as the number of cells with a high proportion of mitochondria containing defective genetic code increases, the body's capacity for energy production decreases.

Cells begin to die and the performance of the body's tissues and organs declines. This eventually leads to a point where the body can no longer meet the environmental demand for continued existence.

But, according to the Monash researchers, because the enzymes further down the line still work perfectly well, it might well be possible to by-pass a single blockage in the energy chain so that the cell can carry on its activities.

In fact, Linnane and Marzuki propose that certain substances, if taken in large enough amounts, can be used to by-pass these "breaks" in the energy chain of cells. These substances are present in common foodstuffs and include Vitamin C, the less well known ubiquinone which occurs in both plants and animals, and a Vitamin K-like chemical, menadione.

A few such supplements are already in clinical use and, the researchers argue, new and more effective supplements could be designed artificially to treat degenerative disease.

Vitamin C was put forward more than a decade ago by Nobel Laureate Professor Linus Pauling as being of benefit in the treatment of many illnesses, even the common cold. Pauling also maintained that it might ameliorate the ageing process and the progression of some cancers.

At the time, however, Pauling and his colleagues were unable to develop arguments or experiments sufficient to convince the wider scientific community of the validity of their claims.

Professor Anthony Linnane, said: "Our hypothesis is simple and appealing. It knits together many observations of degenerative disease. But best of all, our ideas are relatively easy to test."

"It will not be too difficult for us to check if the relevant mitochondrial enzyme activity decreases with age and if the simple kinds of dietary supplements we propose effectively alleviate some of the symptoms of ageing."

Almost all the genetic material (DNA) in the cell is contained in the nucleus. But the genetic code for the enzymes critical to the cell's energy production process sits in the mitochondrion, where energy production takes place.

Only about seven per cent of the nuclear genetic material contains information actually used in the cell. But all of the mitochondrial DNA is important to the cell. So while there is only about one chance in fourteen that a mutation in the nucleus will affect the cell, every mitochondrial mutation influences the cell in some way.

In addition, while the nucleus possesses a system which repairs damaged DNA, thus reducing the impact of mutations, mitochondria have no such system. Further, the measured frequency of mutation in yeast mitochondria is more than 10 times that of the nucleus. The same is assumed to be true of mammalian cells.

Working together on a collaborative project investigating the diseases caused by defects in the mitochondrial DNA, the Australian and Japanese researchers began to put all this information together.

They decided that as mitochondrial mutation probably occurs continuously from conception till death, a growing proportion of mitochondria would become mutant.

Although the number varies with the kind of cell, a typical cell contains between 500 to 3000 mitochondria. When cells divide, the mitochondria are randomly distributed between the two daughter cells.

So, over time, tissues would begin to be composed of a mosaic of cells, some with a majority of mutant mitochondria, others with few. The higher the proportion of mutant mitochondria, the lower the capacity for energy production, reducing the ability of the cell to respond to environmental change.

As humans age, the researchers argue, they adjust their activities to compensate for the energy loss, and the result is the normal symptoms of ageing.

The researchers have in fact found evidence of a decline with age in the amount of energy produced in muscle mitochondria. This data was published in a companion paper by Marzuki and Dr Ed Byrne of Saint Vincent's Hospital, Melbourne in the same issue of *The Lancet* as the hypothesis.
Gene repair is unaffected by age

Birth defects can result from tiny or gross changes in the genetic material. Recent Monash research shows gross changes are the more likely cause.

Most people having children are well aware that the probability of occurrence of certain congenital birth defects — Down’s Syndrome, for example — increases with the age of the mother.

Some birth defects occur because the natural order of the genetic material (deoxyribonucleic acid or DNA) has been upset. This can occur at various levels ranging from a point within a single gene to whole chromosomes, the rod-like structures containing hundreds of genes.

But a report recently published by two Monash geneticists in the scientific journal Mutation Research suggests the effect of age on genetic defects may be limited to those relatively few which, like Down’s Syndrome, involve whole chromosomes.

The research was carried out by tutor Mrs Catherine Guli working in the laboratory of Dr David Smyth.

In sexual reproduction, the two cells which fuse to create a new individual, the sperm and the egg, each contain half the usual number of chromosomes. So the new individual they form has the normal number.

These sex cells are created by a special form of cell division, meiosis, during which the cell divides twice while its chromosomes replicate only once, thus, potentially creating four cells with half the usual number of chromosomes.

But that is not the only strange thing about the way the eggs are formed in mammals. Meiosis begins in the ovaries of a female before she is born, but stops at the time of birth and before the completion of the first division. Only immediately prior to ovulation, when the egg is shed during the menstrual cycle, does the process continue.

That makes eggs among the longest lived cells in mammals. And in humans, therefore, some may remain dormant, but ready to mature, for 40 years or more. Even the youngest is more than a decade old when it matures at puberty.

Such long-lived cells run the risk of accumulating genetic damage, in the form of point changes, or mutations, from environmental hazards such as X-rays or dangerous chemicals.

Cells have natural mechanisms to repair the damage to their DNA. In fact, one possibility is that the risk of some congenital birth defects may increase with age because these mechanisms become less efficient over the years. To test this possibility Catherine Guli measured levels of DNA repair in young and old mammalian eggs.

She took a group of eggs from laboratory mice which had just reached sexual maturity (eight to 14 weeks old), and a second series from mice which were more than a year old, close to the end of their reproductive life.

Then she irradiated the eggs with ultraviolet light to cause genetic damage and activate one of the cell’s DNA repair mechanisms. By nurturing them briefly in a solution which contained a radioactively labelled version of one of the building blocks of DNA, she was able to measure how much of it was built into the DNA where the damage was repaired. Thus she had a gauge of the amount of repair work done in both the old and the young eggs.

What Guli found was that the average amount of repair work carried out in the chromosomes of a large number of old eggs was very similar to that done in a large number of young eggs. So she concluded that, for this type of DNA repair at least, the repair mechanisms did not become less effective with age.

This is reassuring as it indicates that mammalian eggs shed late in life are not necessarily burdened with mutations accumulated over their longer life span.

In contrast, defects involving whole chromosomes do seem to increase with old age, probably because faults in the mechanism by which the chromosomes separate during division occur more often in older eggs.

“Not only do egg cells seem to maintain high levels of repair throughout their long life, but others have shown that eggs can provide the machinery to repair DNA damage in an incoming sperm following fertilisation,” Guli said.
For many plants, mite is right

A large number of plants house mites in special bumps or pits on their leaves. Recent work at Monash suggests this is a very ancient relationship from which both sides benefit.

If you pick a leaf from a tree in one of the wetter parts of the world, such as North Queensland, there is a good chance that on the underside, in the angle where the spreading veins meet the central vein, you will find some small bumps or pits.

And if you take the trouble to cut one of these open under magnification, there is an even better chance that inside will be a mite — an eight-legged creature like a cross between an insect and a spider and no bigger than the point of a pin.

The leaf bumps or pits are called domatia, and an ongoing study by a research team in the Botany and Zoology Department has found that they are very widespread, occurring in 25 per cent of the families of woody flowering plants. While uncommon in arid areas, they are very frequent in rainforest vegetation.

But why are they there? The researchers believe all the evidence suggests that plants grow them deliberately to shelter mites. In return the mites either protect or groom the leaves by eating other small creatures which feed on leaves or removing parasitic fungi.

If this hypothesis of a mutually beneficial relationship turns out to be correct, it would be the most widespread and ancient example of such a link known.

And this would open up two interesting prospects. As the wild relatives of several agricultural crops are among the plants that carry domatia, it would open the potential for improving crops by learning to manage better this form of biological pest control and by introducing it to new crop strains.

The second benefit would be the discovery of a manageable system for studying one of the great unknowns of ecology — the cooperation between species known as mutualism.

Research team leader Dr Dennis O'Dowd says: "Interactions between species are a glue holding biological communities together. The three most important interactions in this respect are those between predator and pray, competition between species for a scarce resource and mutualism."

"Comparatively little work has been done on mutualism, although it could be very important to the understanding of the biological world. Very large experiments on mutualism could be set up in a small space, using the plant-mite system."

The existence of domatia has been known for more than a century. They come in four types known as pits, pockets, pouches and tufts.

The suggestion that domatia house mites which protect leaves has been around for almost as long as domatia have been known. It first was proposed by the Scandinavian biologist Axel Lundstrom in 1887, but was subsequently discarded by the scientific establishment for lack of evidence.

In 1986, O'Dowd became interested and decided to collect evidence to settle the matter one way or the other. He took the word collect very literally. In an initial study of the 37 Australian species, taken from as widely apart as Papua New Guinea and the South Island of New Zealand, members of his group gathered five leaves from five shoots of five trees of each species, and ended up with tens of thousands of domatia. (The collection has now expanded to 43 species — more than 40,000 domatia.)

The first task was to demonstrate whether or not mites were associated with domatia. This was done by examining the domatia for any evidence of mites, either the animals themselves, or their eggs, or even their faeces.

In fact, mites accounted for about 90 per cent of insect-like creatures in domatia. They occurred in about half the domatia and on about 70 per cent of the leaves, with a preference for older leaves.

That was the easy part. Determining why the mites are there is much more difficult. Over the years several hypotheses have been put forward, not all of them mutually exclusive. Gathering evidence to decide which explanation is most likely is a long and ongoing process. Still, the researchers have made a good start.

It is easy to show that domatia are grown by plants deliberately; that they are not galls formed as a reaction to mite invaders. Not only do domatia grow in the absence of mites, but they can also be detected in embryonic leaves within the bud. They occur in particular species of plants, and their presence, form and positioning is so regular that it can be used as a characteristic to tell species apart.

The structure and position of domatia would seem to suggest that they are not specialised for use by plants as glands or insect traps, or for absorbing water or gases.

One hypothesis even suggests that they are provided by plants as "mite toilets", the plants breaking down the faeces for fertiliser. But there appears to be no internal structure for absorption of such nutrients, and there is no biochemical activity which would suggest such a breakdown process.

The researchers found that the mites harbored by domatia fell almost exclusively into two groups: mites which feed on fungi and other parasites on leaves, and predatory mites which eat plant-damaging insects and mites, their eggs and larvae.

So it would seem to be useful to the plants to have such mites around. But what do the mites get out of it? O'Dowd said: "Most mites have a very thin outer coat or cuticle, so they lose water easily and are very sensitive to humidity. Domatia provide them with a useful humid shelter where they can lay their eggs in safety and gain a measure of protection from the things that eat them."

During the course of its work, the research team has discovered that the relationship between mites and plants goes back a very long way indeed.

Palaeobotanist Dr Dave Christophel is studying ancient assemblages of leaves trapped and mummified in the Anglesea coal field and in a sand mine at Golden...
The mite on the left has been preserved for 43 million years in an Anglesea coal seam. On the right is a modern relative.

Grove, near Adelaide. These leaves have been preserved from a rainforest which was growing in the mid-Eocene, about 43 million years ago. And on the underside of their leaves, many display domatia.

Having found these ancient domatia on leaves from trees which are closely related to those found in the modern rainforests of North Queensland, the group became excited enough to start looking for mites. They found them — so far, mites from three different families which live on leaves.

So the group now has a firm foundation for future work. O'Dowd is particularly interested in exploring the mite-plant relationship experimentally, investigating its consequences for both the plants and the animals.

For instance, one obvious experiment which can be pursued both in the laboratory and in the field is to check what happens if mites are denied access to domatia.

"You can fumigate plants, block up the domatia with paint and see whether it disadvantages those leaves or plants. Do damaging organisms increase on the leaves? Does leaf damage itself increase, especially near to domatia where the 'protective' mites live? Is there any effect on shoot growth?"

A similar experiment can be used to investigate the mite side of the relationship. The group intends to examine whether blocking domatia influences the reproduction, distribution and longevity of mites.

In addition, collection of basic data and research into some of the other hypotheses of the mite-plant interaction will continue. For instance, the team hopes to establish if there is any pattern of mite occupancy of domatia throughout the year, if more mites shelter in domatia at any particular time or if different types of mites occur in the domatia in different seasons.

The work on the history of the association between mites and plants will also continue, trying to determine how widespread and frequent it was in the past, particularly in species with close affinity to contemporary species.

O'Dowd said: "This is a whole new system for studying the pattern of mutualism and we are one of a very few research groups active in studying it."

This work was initiated with a grant from the Monash Special Research Fund, and since then has been supported by the Australian Research Council and the US-Australia Co-operative Research Program.

Other workers involved in the project include Professor Mary Willson of the University of Illinois; Dr Eberhard Schicha of the New South Wales Department of Agriculture; Dr David Christophel of the University of Adelaide; PhD student Dugal Wallace; research assistant Chris Brew; and technical assistant Tarmo Raudik.
Playbox Theatre comes to Clayton

The University's Alexander Theatre, in conjunction with the Playbox Theatre, is to present Australia's first suburban season of professional drama. Play Season '89 will consist of two regular Playbox productions Nice Girls from 19 to 22 July and Coralie Lansdowne Says No from 9 to 12 August, together with Sydney's Phillip Street Theatre production of Educating Rita from 11 to 15 July.

Speaking about the season, the Vice-Chancellor, Professor Mal Logan said: "We are near the demographic heart of Melbourne and we have a first-rate theatre. This season allows us to serve the enormous population in our area as well as the university itself.

"Many of these people find it too time consuming to travel to the city, even for first class entertainment. Now we are bringing the Playbox Theatre to the people."

The manager of the Alexander Theatre, Mr Phil A'Vard said: "The Playbox Theatre will extend the season of their two plays by a week and move them out here. We hope that Monash audiences will develop a taste for them, because this venture opens up a brand new world of possibilities of working in conjunction with mainstream city theatres."

Links between the Playbox and Monash go back to the early 70s when the Playbox began holding workshop readings of new Australian plays on campus. In the mid-70s the Alexander Theatre "borrowed" the present artistic director of the Playbox, Carrillo Gantner, to star in several of its homegrown productions.

Gantner sees the Monash experiment as a chance for his theatre to spread wings. At the moment, in the city, the Playbox is catering only for a tiny part of the potential audience in Melbourne.

A'Vard puts it more succinctly: "Nowadays, Monash isn't too far out. The city is too far in."

But there are other advantages of the link, besides the obvious ones of joint finance and promotion.

The Playbox hopes to tap into the university's Department of English which has been at the forefront of dramaturgy and playcraft in Victoria. Dr Dennis Bartholomeusz, for example, is a world authority on theatrical performance, particularly of the history of Shakespearian performance.

And that could lead to the possibility of originating productions at the Alex and taking them to the city.

Australia's first suburban professional season is another boost for a theatre which already has established itself as an international centre of children's theatre. When English puppet favorite, Sooty, and his faithful sidekick Matthew Corbett toured Australia to sellout audiences last year, the UK promoters booked the Alexander Theatre because "it has the children's theatre following in Melbourne."

To Phil A'Vard this was a delightful confirmation of the value of more than 18 years of working to build up children's theatre at the Alex and in Melbourne generally.

This year the two Saturday Club children's theatre subscription series are fully booked once again. And the Alex has a solid program of bookings of community activities and student theatre.

As for Play Season '89, if the three plays chosen do not entertain suburban audiences, almost nothing will.

Coralie Lansdowne Says No is widely regarded as Alex Buzo's best and funniest play. A no-holds-barred, wisecracking, thinking woman, Coralie is about to turn 30, wanting to be brilliant, but discovering that perfection, especially in men, is hard to find.

Linden Wilkinson's Nice Girls is a delicious comedy about an unscheduled reunion of old friends at the beach, with husbands and lovers in tow. It scans envy, adultery, treachery and friendship.

And Educating Rita, the play behind the film of the same name, already is a minor classic. Willy Russell's play is a modern-day Pygmalion story about the impact of the Open University system in pre-Thatcher Britain on a young, unpretentious, working-class girl. The scenes are a set of tutorials and confrontations with her tutor, Frank.

When Monash opened its doors in 1961, it was claimed that the campus lay in a cultural wasteland. More than a quarter of a century later, the Alexander Theatre is helping to make the people of Victoria aware of the transformation that has taken place.

For further information, contact the Alexander Theatre on (03) 565 3992.

MONASH REVIEW

The Alex: an international reputation for children's theatre.
Centre markets microwave expertise

**THE MONTECH FILE**

The University's technology and consulting company, Montech Pty Ltd, has become the sole Australian agent for the US-based Millitech Corporation which produces high technology microwave subsystems.

Such subsystems are used in equipment important to communications, radar and remote sensing, electronic interception, radio astronomy, physics research and science, and their role will increase in significance as these areas develop.

Montech will use members of the Chemistry Department's Centre for High-Electronic Technology as technical consultants to help it sell the Millitech products.

Deputy director of the centre, Dr Peter Godfrey said: 'It's a good practical business proposition. Millitech has already made substantial sales in Japan, for example. Initially our market will be in defence science, telecommunications and radio astronomy.'

The centre employs such specialised high frequency microwave subsystems in the equipment it uses in research on the molecules found deep in space. These molecules are detected by analysis of the microwaves they emit.

In fact, researchers in the centre have had to manufacture their own specialised hardware, and the role will increase as these areas develop.

'Selling such microwave products is a very specialised business. You have to be familiar with the product line and so can assist with choice, but we also are able to test the component before delivery to ensure things are right,' Godfrey said.

It is not really surprising that a group like the centre should become involved in selling the Millitech equipment, for Millitech itself was founded by a small group of academics at the University of Massachusetts.

Godfrey said: 'They are colleagues in radio astronomy, and we have collaborated with them for years. We knew the principals of the company well before its inception. When they saw how we were using their equipment, they approached us with the idea of acting as sales representatives.'

'The arrangement with Montech was recommended by the university as the most appropriate way of doing this. The advantage of an organisation like Montech being able to provide the legal and commercial support should not be underestimated.'

Other products the centre markets through Montech include high voltage square wave generator, a four-channel gated integrator and a microwave source controller. There are also two computer programs: Chemmand, a chemical stores management and information system and MacSimion, a simulation and design package for charged particle beams.

For further information, contact Dr Peter Godfrey of Chemistry on (03) 565 4537 or Dr Paul Hudson of Montech on (03) 565 5055.

---

Computer measurement sells

**UPDATE**

The University's Intelligent Robotics Research Centre is now marketing a fast, accurate computerised surface shape measurement system developed by its members (see Monash Review 6-86).

One system already has been sold to the Biochemistry Department at the University of Western Australia for breast volume measurement in research on human lactation. Another has gone to a private computer vision company in South Australia. It also is being used as a vision system in advanced robotics research at the centre.

The system measures the position in three-dimensions of a set of up to 8096 points which define the surface shape of an object. Using this data, programs can be written to calculate surface area, volume and cross-section, for example.

Dr Kim Ng, who led the research team which developed the system, says: 'The great advantage of our system is that it is based on liquid crystal technology so there are no moving parts. This makes it fast, reliable, accurate and inexpensive in comparison with competing laser-based systems. In addition, it is safe and portable.'

A projector attached to a computer throws a pattern of 64 horizontal stripes onto any shape over a field which can range between 25 mm and 2000 mm. The resulting image is recorded by a video camera/frame grabber.

On a completely flat surface, the stripes would appear regular, parallel and straight. But any deviation from flatness distorts the stripes, and the computer can use the difference between the straight and the distorted images to construct a three-dimensional model of the shape.

It calculates the distance from the camera to each of up to 128 points along a stripe by means of triangulation, using the distance between the camera and the projector and the angle subtended at the object.

The full system, including computer, camera, frame grabber, special projector, and computer software, costs about $35,000, cheaper than most similar systems.

Ng said: 'It can be used in manufacturing, for ensuring that parts which need to be precisely fabricated have no faults. For instance, our machine could quickly and accurately confirm that a casting had been formed in the exact shape required.'

He said the system was under active development. A means was being tested by which views from several camera angles could be merged, giving a full three-dimensional shape description. The group also was experimenting with a higher definition system, he said.

For further information, contact Dr Kim Ng of the Department of Electrical and Computer Systems Engineering on (03) 565 3471 or fax (03) 565 3454.
Hospital waste a health risk

From Page 1

"You have to look at the entire problem — how the waste is generated, stored, labelled, packed, and transported as well as disposed of," Clarey said.

The four set up a research program which included collecting data using an experimental incinerator, as well as surveys and interviews with hospital personnel involved with handling cytotoxic materials and with waste management.

Tacey said what they found on their hospital visits disturbed them. "A significant proportion of the workers, who were concerned about the effect of cytotoxic waste on their health, were unhappy with the procedures for handling them."

"Previous research has reported that some of the hospitals turn down the temperature of their incinerators to conserve gas. And several of the incinerators were positioned so that their smoke could be sucked into hospital air conditioning systems."

A standard hospital incinerator consists of three parts (see diagram). Waste material is loaded into and ignited in a primary chamber. The smoke and volatile compounds emitted move into a secondary chamber where they are burned off using gas after-burners. From there they proceed up the chimney and into the atmosphere.

The experimental incinerator constructed for the research team included three secondary chambers, each containing a port through which samples could be taken. The elongated secondary chamber area allowed the students to study emissions which had remained in the incinerator for different lengths of time.

In order to eliminate the air pollution caused by dirty test burns, the experimental incinerator also was fitted with a tertiary chamber incorporating a high temperature burner to clean up the discharge. The primary chamber was set to burn at about 600 degrees Celsius, and the tertiary at about 1000 degrees Celsius, while the secondary was able to be varied between 600 degrees and 1000 degrees.

The team conducted 15 experimental burns with the incinerator. For the first four burns, the researchers simply ran the unit without waste, to test the equipment, refine their procedures and provide blank samples for future tests for cancer- and mutation-causing substances.

In the next four burns, the team burned typical cytotoxic waste from a hospital cancer ward. During the first of these, the group deliberately set the secondary chamber temperature low to test the worst possible case.

For burns nine and ten, the team burned unused, uncontaminated hospital plastics and in burn 11, non-cytotoxic waste. The last four burns contained plastics and non-cytotoxic wastes spiked with known amounts of cytotoxic drugs.

During the test burns, the researchers collected samples from the ports and tested them for polycyclic aromatic hydrocarbons — a group of compounds many of which are known to cause cancer. These samples, together with samples of the particles carried in the smoke, were also put through the standard Ames test to see if they caused an increase in the mutation rate of bacteria.

To determine the progress of burning, the group also tested the proportions of common gases emitted — oxygen, carbon dioxide, carbon monoxide, sulphur dioxide, and nitrous oxide. And the ash in the primary chamber was analysed for heavy metals and to see whether it caused mutation.

From the results there is little doubt that cytotoxic waste has to be handled carefully. With the exception of burn seven, where the temperature in the secondary chamber was very high and there was sufficient oxygen, all the experiments where cytotoxic drugs were present gave off significant quantities of carcinogenic and mutagenic compounds.

As expected the dirtiest burn was burn five where the temperature was kept low in the secondary chamber and the level of oxygen was undetectable. Burn seven, where there was plenty of oxygen and the temperature in the secondary chamber went as high as 1150 degrees Celsius, was clean, demonstrating the effectiveness of high temperature and oxygen in breaking down cytotoxic wastes.

As a general conclusion, the report states, "It is unlikely that hospital incinerators operating at less than 1100 degrees Celsius, are adequate for the effective destruction of cytotoxic waste." In fact, the results from four of the burns showed that at lower temperatures, the conditions in the incinerator can actually aid the formation of carcinogenic compounds.

Analysis of the ash left in the primary chamber showed it to contain physical hazards in the form of sharp needles and glass, as well as significant quantities of some heavy metals.

In addition, water washing through the ash can leach out high quantities of aluminium, cadmium and zinc, so careful disposal is necessary to avoid polluting nearby water sources.

The report makes a series of recommendations on development of hospital policy for disposal of cytotoxic wastes, and calls for training of the hospital personnel who deal with such substances.

It also recommends medical reports be kept on the health of such people. "We just don't know the effect exposure to low levels of these substances has on the health of workers over 20 or 30 years," Tacey said.

The researchers say that cytotoxic waste should be carefully segregated from other waste and labelled.

As for the operation of incinerators, the report recommends adoption of the EPA guideline of 1100 degrees Celsius for at least one second, and calls for monitoring and control systems to be fitted to ensure there is adequate oxygen available at all times for complete combustion.

It also recommends careful positioning, regular maintenance and EPA monitoring of hospital incinerators.