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**ABSTRACT** SI/86/B(4)

# ENVIRONMENTAL, ETHICAL AND SAFETY ISSUES IN CHEMISTRY/SCIENCE CURRICULA IN PAPUA NEW GUINEA PROVINCIAL HIGH SCHOOLS.

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Chemistry occupies only a small portion of the Papua New Guinea science curriculum in grades seven to ten. Science itself occupies only a small proportion of the total curriculum. Nevertheless the existing syllabus, and previous and planned future revisions of it, give considerable prominence to environmental, health and safety issues. There is a fundamental implicit ethical position within all Papua New Guinea curricula which comes from the philosophy of the 'blending of cultures', put forward initially by F. E. Williams in the 1930's.

Same chemically related health issues in Papua New Guinea Science Syllabuses are alcohol and tobacco abuse, betel-nut chewing and pesticides, and this paper will place more emphasis on these issues as they relate to chemistry portions of the syllabus.

Papua New Guinea is a developing country in which extractive industries occupy a prime place in the local economy and the syllabus gives emphasis to one of these industries (the mining of copper ores), though it hardly mentions the effect of this industry on the environment.

Over the years the syllabuses have changed and improvements have been made in the experiments demonstrated to or performed by students and this care for the safety of students is in itself an ethical statement.

Finally the paper will criticise the lack of a quantitative base in science/chemistry curricula in Papua New Guinea on the grounds that the absence of this denies aspiring young Papua New Guinea scientists the means of comprehending the intellectual and ethical foundations of 'Western' scientific thought.

# ENVIRONMENTAL, ETHICAL AND SAFETY ISSUES IN CHEMISTRY/SCIENCE CURRICULA IN PAPUA NEW GUINEA PROVINCIAL HIGH SCHOOLS.

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## INTRODUCTION

Papua New Guinea is very much a third world country in terms of development. It has a population of about 3 million people, a very high rate of population growth, and geographical disadvantages such as huge mountain ranges, and large rivers and extensive tropical swamps. Apart from the main island, the country also consists of several widely spaced archipelagos: all these factors make communications difficult and favour the evolution of air transport and telecommunications rather than road transport. This is precisely what has happened, but unfortunately educational development has been slow. Prior to 1962 there was virtually no secondary education and this is why it was only in the late sixties that higher education got under way. We thus have a country which depends upon modern technology to exist, but whose culture and whose educational philosophy are basically ‘anti-scientific’. This is one paradox which has to be considered in the development of science curricula at a secondary level, yet the paradox is scarcely recognised. It is possible for the country not to face up to the problem, because it is economically quite wealthy, at least in third world terms.

Overseas ‘experts’ such as teachers, mechanics, telecommunication engineers mining engineers, bank managers, accountants, etc are imported, but their services are expensive. The economy relies on agricultural crops such as coffee, copra, palm oil, cocoa, tea, cardamom and pyrethrum, minerals such gold and copper ores and ‘Australian aid’. Each of these financial resources has undergone some difficulty in recent years so the government is again looking at ways of reducing its costs, particularly those of expensive foreign labour. This is understandable but it is unlikely to be successful in the short term. The foreign experts almost all have some skill dependent on mathematical, scientific or technical expertise.

The long term problem for the country is that these skills are not being properly inculcated into young citizens at an early enough stage in their intellectual growth, so prospects of an up and coming scientific elite to serve the country’s manpower needs are dim.

## CULTURE AND PHILOSOPHY

There are more than 700 different language groups each with its own separate culture so it is not possible to generalise too widely. F. E. Williams (1935) put forward the idea of a ‘blending of cultures’ in which the good parts of local and western culture were reinforced and expanded and in which the evil parts were expurgated. This perhaps expanded an earlier formulation of the idea by Huxley (1932) ‘to blend what is good in their tradition with 'that is a good in the tradition of western civilisation’. This idea was enlarged upon by Groves (1938) who considered education:-

1) as an agent of natural growth and evolution,

2) as serving the mass of natives not a select few

3) as an agent of cultural preservation, yet

4) pursuing adaptation of local life and institutions in conformity, with modern ideas.

These ideas formed the basis of Groves' policy when he became Director of Education after the end of World War 2. He was recently' described (Griffin, 1986) as ‘a visionary but impractical man’. However the present day work of those preparing the curricula for primary and secondary schools is still very much influenced by these ideas. This can be seen in some comments on recent curriculum development by Ilagi (1980).

> Communities and cultures change. The community may not want to keep some old and bad customs. Other changes will come because of contact with new ideas, new ways of doing things and other cultures. Rather we have what we hope is a practical amalgam of elements of sundry philosophies, an amalgam which aims to foster both individual and national development. (Ilagi, 1980).

One problem with the philosophy is the question of who makes decisions as to which aspects of culture should be preserved and which should be removed. The next problem is how to preserve or destroy culture, and finally there is the problem of the emphasis in Western Science being on individual achievement whereas Groves insisted that ‘education should serve the mass of natives’ not an elite. This last philosophical problem was perhaps the main reason for the slow progress of education during Groves’ period as Director of Education.

## PAPUA NEW GUINEA PROVINCIAL HIGH SCHOOL SCIENCE CURRICULA

In Papua New Guinea, there are 115 Provincial High Schools which educate 44,420 pupils between grades 7 and 10. Pupils have forty periods a week of forty minutes duration each week during the school year. Of these only five periods per week are for science. This is a lower proportion of time spent on science than in most countries. The overall science syllabus is not quantitative and this aspect of science in teaching has previously been strongly criticised (Palmer, 1984). Other recent papers on different facets of the secondary science curriculum in

Papua New Guinea include Deutrom and Wilson (1986) who broadly favour the present curriculum, Maddock (1983) over viewing curricular progress over two decades, NDOE (1985) detailing the current secondary curricula, Palmer (1985) giving a detailed breakdown of the syllabus relating it to teacher training syllabi, Owens (1980) describing secondary upper secondary and tertiary curricula, Palmer (1986) looking at science teacher's limited knowledge of secondary chemistry content and Calder (1986) looking at likely changes in upper secondary curricula.

There is thus a wealth of material on the science curricula in Papua New Guinea, some of which is simply descriptive, some of which is critical of the existing syllabus for its lack of an empirical base, some of which criticises the syllabus for being over-academic causing alienation between secondary students and the community and some of which is supportive of the existing syllabus. However this paper will examine health, ethical, safety and environmental issues pertaining to the secondary science syllabus in Papua New Guinea.

## PAPUA NEW GUINEA SCIENCE CURRICULA AND CHEMICAL RELATED HEALTH ISSUES

### Agricultural Chemicals

Unit 5 entitled Ecology (p. 47) in Grade 9 gives some idea of the harm which can be caused to the environment by chemical sprays, through there does not appear to be a great emphasis on the possible dangers to agricultural workers through the careless handling of agricultural chemicals or from drinking chemicals. In 1980, some villagers accidentally mistook ‘Gramoxone’ in a wine bottle for ‘Communion’ wine and there were several deaths.. (PC.1986, 4 references). Whether improved education could prevent such accidents is doubtful but chemical companies have of late done work to reduce the risk of such accidents.

### Smoking

Unit 6 (The Body) in Grade 9 (p 85) shows some of the risks of cigarette smoking and its relation, to lung cancer, though its relation to the chemicals in cigarettes is not stressed. In the highlands, where it is very cold on some nights, village houses have fires inside with no chimneys so that the atmosphere inside, through warm, is extremely torrid, and although the possible dangers of this smoke pollution are briefly mentioned in the syllabus, there should perhaps be greater emphasis.

### Betel-nut chewing

In Papua New Guinea chewing betel-nut with lime and mustard, giving the familiar red stains on the lips and on the ground when the red juice is expectorated, is extremely common amongst villagers and the educated alike The nuisance caused by the red colour disfiguring walls, streets, etc. has led to its being banned in Eastern Highlands Province though the ban is ineffectual. The

village lime, used when chewing betel-nut, is employed in the experiments showing the differences between limestone, quicklime and slaked lime in Unit 10 1 entitled 'Chemical Technology' (p 35). Betel-nut chewing is also given as an example of chemical change in Unit 1 Grade 8, p.16. One of a number of articles on the chemical of the betel-nut (Farnworth, 1976) indicates in fact that some of the chemistry particularly of the colour change to red is not fully understood. No mention in the syllabus is made of the local methods of making and marketing the lime, even though this is now quite a substantial local industry, albeit on a small scale. There is a most interesting paper on this by Mahoney at al, (1985) which would make good syllabus material. More importantly no mention is made of the considerable throat cancer risks caused by chewing betel-nut, due to its carcinogenic properties. The lime also causes terrible tooth decay which creates considerable dental problems. At some point within the syllabus the writers should attempt to discourage betel-nut use, as its very considerable popularity and wide-spread usage will present major medical problems in the future.

Alcohol

The consumption of alcohol in Papua New Guinea, as elsewhere in the world, wreaks its accustomed havoc with human lives and happiness. In Papua New Guinea, a very high proportion of newspaper headlines seem to relate to alcohol abuse in one way or another; the science syllabus is strangely quiet about this.

In the most recent grade 8 syllabus, Unit 1, p 28, there is an experiment on distilling beer. Experimentally it is unsatisfactory due to the tendency for the beer to froth over-into the condenser and also because very little alcohol distills into the condenser anyway, due to the small percentage of ethanol in the beer. None of the social problems of beer, wine, or spirit drinking are mentioned.

The drinking of methylated spirits appears to be increasing as a recent report indicates. P.C. (1986) states that one man died and another was blinded by drinking 'Meths'. There is fairly frequent mention and use of methylated spirits in the syllabus for a variety of purposes, for example as an analogy to sweating (Grade 9, Unit 6, Our Body) and as a fuel (Chemical Technology; Grade 10, Unit 1, 1976 edition). In this regard it is interesting to note ethanol from the fermentation of sugar wastes is added to petrol sold in the highlands as a means of lowering foreign exchange costs of petroleum imports to the country (Hiambohn, 1983). Neither the benefits nor the unfortunate social consequences of ethanol are given any prominence in the syllabus.

Drugs, Medicinal Plants and Aflatoxins

Apart from the drugs such as tobacco, betel-nut and alcohol previously mentioned, drugs such as cannabis, heroin, etc. are a considerable social problem in many countries. As yet they do not appear to be a significant social problem in Papua New Guinea, though cannabis evidently grows

well in the highlands. Chemical procedures for helping drug detection agencies have been devised at the University of Papua New Guinea. (Drover & Lacanienta, 1980).

Medicinal plant research has been a popular area for chemists: there have been a series of papers by Holdsworth, for example (Holdsworth, 1975: 1978) on medicinal plants, but as yet the results are limited in practical application, through there are perhaps some aspects of this which could be mentioned in the syllabus to stimulate thought from students, who may have a good knowledge of plants used medicinally in their own areas.

Beard and Lacanienta (1982) investigated the occurrence and concentration of aflatoxins in local and overseas peanuts and peanut butters. They explain that very small amounts of aflatoxins can cause liver cancer, but indicate that all the samples they tested were within recommended safety levels. They showed that the local product had improved considerably since earlier tests. Their advice on throwing out discoloured looking kernels might well be valuable to pupils. However a later survey of the peanut butter produced locally showed some extremely dangerous concentrations of aflatoxins (Varssilli, 1984) which combined with management problems, led to the demise of that local industry. All the above seem to be placed in the 'too hard' file as none receive a mention in the syllabuses.

## SAFETY IN THE SCIENCE CURRICULUM

The improvement of standards of pupils' safety in schools is itself an ethical statement. In the United Kingdom, Borrows & Turner (1984) state:

> Science teachers have a difficult tightrope to walk in seeking to balance the known hazards of particular chemicals and processes against the educational advantages of using them. (Borrows & Turner, 1984)

Borrows and Turner also report that the laboratories are one of the safest places in schools (safer than the toilets for example) and that schools themselves, compared with accidents in the home, at play and on the road, are also comparatively safe places. In third world countries, dangers from disease, malnutrition, etc are much increased and the amount of experimentation in school laboratories is frequently reduced so the laboratories in third world countries are very safe places in comparative terms.

The author knows of no statistical evidence on laboratory accidents in Papua New Guinea: but they would seem to be very infrequent events. It is thus to the credit of the curriculum developers that general levels of safety of the experiments within the syllabus have improved over the past fifteen years without making the experiments themselves any less exciting. Some issues relating to safety from the Papua New Guinea curriculum will be explored.

The Mercury danger

In earlier versions of Unit 1 Grade 8 (p. 24 in the 1974 version) (p. 29 in the 1979 version) mercury II oxide is heated as a teacher demonstration experiment to show that some compounds can be split into their elements and that there is a loss in weight due to the oxygen evolved Mercury is seen as a condensed liquid in the cooler parts of the test tube. Unfortunately the experiment produces quite high levels of mercury vapour.

A recent article by Moore &Timbs (1984) explains some of the dangers when using mercury. In Papua New Guinea, Holdsworth (1975) very strongly criticised the experiment on safety grounds. These were the production of mercury vapour and the disposal of the excess mercury II oxide down the drain.

The experiment was also correctly criticised for being unsuitable for quantitative work: this is ironic in that it was one of the few quantitative investigations in the curriculum and the only one in unit 8.10. The science curriculum officer of the time strongly rebutted the criticisms of the experiment, perhaps over reacting somewhat. The truth was that, carried out in the way 'the experiment was intended (in a fume cupboard or in the open as a demonstration), it was indeed quite safe, but carried out as had been seen by the critic in some schools as a class experiment, it was indeed dangerous. Circumstances alter cases.

The rebuttal did contain an interesting statement that ‘the experiment in the final version is as safe as any chemistry experiment’ (Deutrom, 1976); this statement in itself is food for thought. It is of some interest that in the 1985 version of Unit 8.1 the experiment has now been omitted and replaced by another experiment. There is some local relevance to this experiment in that local alluvial gold miners use mercury to separate gold they have panned from stones and sand and are almost completely unaware of its dangers. The Chemical Technology Department at the University of Technology, Lae recommended that local miners should be made more aware of the possibility of mercury poisoning (Mallard & Blowers, 1986). Should syllabi on occasions, include more dangerous experiments to teach pupils how to handle dangerous substances correctly?

The Volcano experiment danger

The decomposition of ammonium dichromate is always an exciting experiment to perform and pupils enjoy it too. Obviously Papua New Guinea syllabus writers themselves like the experiment as it currently occurs twice, once in Grade 8, Unit 1, p. 8 and once in Grade 10 Unit 4 (Geology). It is perhaps in this latter experiment, which seeks to imitate a real volcano that insufficient attention has been paid to safety.

It is suggested that the experiment be carried out in a semi-darkened room (presumably this involves the closure of doors and windows). The dust is currently considered as a likely carcinogen. The volcano experiment using ammonium dichromate VI should only be done as a

demonstration experiment and then only if in a fume-hood (Coble & Hounshell, 1980); Papua New Guinea schools usually have fume cupboards, though not hoods.

The Association for Science Education (A.S.E.) in the United Kingdom (Anon, 1980) believe ammonium dichromate safe enough for use with senior pupils, so the case is not fully made, but it would probably be advisable to modify the instructions for the volcano experiment in the geology unit, so that it is done out of doors or in a fume cupboard.

The Asbestos Danger

In the United Kingdom, the ASE (Anon, 1980) suggest the removal of all asbestos from laboratories, Ainscough & Brodie, (1984) give details of the different dangers dependent on the type of asbestos being utilized and Tingle & Goodfellow (1978) point out some uses for which it cannot easily be replaced.

In Papua New Guinea, a circular has been sent to schools advising that asbestos be replaced with 'ceramic materials' (Deutrom, 1981). The material was used as a centre for gauzes and in various chemical experiments. With the limited equipment available in schools the replacement of asbestos is not generally difficult through on balance risks from asbestos are probably very minor. The replacement of asbestos with ceramic materials is advised but it still has to be shown that the fibres of the ceramic materials are risk-free. There is the further problem that the government schools in Papua New Guinea are built from 'Fibro' ( a prefabricated material) which is believed to have asbestos as one of its constituents. Probably the asbestos danger in Papua New Guinea schools is a little overstated: however not much has been done to ensure that the advice given has been carried out.

Other dangers

The danger from potassium chlorate explosions in the preparation of oxygen has been further reduced by, suggesting the use, of potassium permanganate in preference in the latest curriculum materials. This is sensible.

The danger from carbon disulphide, a suspected teratogen, has been removed by omitting the experiment to separate iron and sulfur using carbon disulphide as a solvent for the sulfur. This too, is a wise move.

Further reduction of dangers

Although the measures described above are generally sensible, the next improvement in safety for Papua New Guinea would be the use of eye protection for all pupils. There are costs involved of course but it would seem to be the most effective single action to take to improve safety in Papua New Guinea secondary schools still further. Borrows & Turner (1986) point out that in the UK a fifth of all accidents in school laboratories are to the eye. Perhaps a further minor

precaution in Papua New Guinea would be to reduce the recommended bench reagents' strength for caustic alkalis from two molar (2M) to one molar (1M) or less.

## THE ENVIRONMENT AND THE SYLLABUS

The chemical problems of the pollution of the environment receive comparatively little attention in the syllabus. Unit 1 of Grade 10 deals with the production of copper as an example of chemical technology. (Ponnamperuma & Palmer, 1987). There is no mention in the syllabus of the pollution of the environment in this unit though some slides by Palmer showing the copper ore mine at Panguna should soon be produced for schools (Hughes, 1986). A few of these slides indicate environmental problems.

The copper/gold mine at OK Tedi has been producing gold for about eighteen months and copper for only a few months. The history of the establishment of this mine is marred by a number of major ecological disasters including the predicted collapse of the tailings dam (Chakravarti, 1984), the spillage of cyanide drums in the mouth of the Fly River. (P.C., 1984, 4 references) and various other smaller cyanide spillages (P.C., 1984e). There are varying views about the environmental damage likely to be caused by the project. Brooks (1986) is optimistic. A recent detailed report by Mowbray (1986) expresses extreme concern about many aspects of the project, including the levels of suspended solids, heavy metals especially copper and free cyanide in the Fly River and its tributaries. A further concern is the lack of monitoring by independent scientists along the Fly River and in the Gulf of Papua.

Papua New Guinea is needed a fortunate country geologically in that it has many proven mineral deposits, particularly gold. There is still a productive mine at Wau and there are excellent prospects at seven other sites: these are Frieda River in Sepik Province, Porgera in Enga Province, Lihir Island in New Ireland, Wild Dog in East New Britain, Laloki in Central Province and Wapolu and Misima in Milne Bay Province (Chakravarti, 1986: Stewart & Lanz, 1985).

These may well come into production over the next few years dependent on the price of gold and the richness of the deposits. The lessons of Ok Tedi are that regular monitoring is required in all new mining ventures to ensure that basic data about pollution is known, but the government will to achieve this does not appear to exist.

Another heavy metal contaminant, mercury, appears to exist naturally in the Lake Murray area (Kyle & Ghani 1982) and the same authors discovered higher than recommended values of methyl mercury in imported tinned fish which is a basic food of most citizens of Papua New Guinea (Kyle & Ghani, 1981). These are all aspects of science applied to everyday life that could be used in syllabus materials to increase their relevance. It is planned that the new syllabus for Unit 10.1 will contain a section on nuclear power including one objective which is to ‘understand the terms radio-activity and radioactive fallout and their effects on the environment and all living things’. This should give some scope to teachers and their pupils to consider the ethics of the ‘Faustian bargain’ (Francis & Abrecht, 1976) struck by the super powers.

## CONCLUSION: EMPIRICISM AND ETHICS

The Papua New Guinea science curriculum has its strengths and weaknesses. The weaknesses arise from the limited time given to science in the school curriculum and to the lack of emphasis on the empirical basis for science students in Papua New Guinea thus receive in their high schools an incomplete and partially false impression of the nature of science: this is ethically wrong. Of course, an emphasis on empiricism does not always lead to a consistent search for truth, for example the recent case of invented results on the contraceptive pill. (Deer, 1986): Also there is a whole history of fraud in science (Broad & Wade, 1985).

Nonetheless in spite of the imperfections and the philosopher's doubts about the exact nature of discovery, the general rule is that widespread empirical research eventually leads to economic advantage. It would be a pity if Papua New Guinea failed economically, due to a wrong emphasis in its science curriculum in schools. This is the major criticism of the syllabus presented in this paper, but it must also be stated that many other facets of the syllabus are excellent. The curriculum gives only limited emphasis on environmental issues, and this should be increased. The curriculum developers have attempted to increase the safety of the experiments within the syllabus and have given considerable attention to important general health issues; a few suggestions for improvement have been given in this paper.

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