Fire Ecology

What is the effect of temperature on mineral content and pH in Alfisols?

Defining the problem

As Australia has recently been subjected to a large number of severe bush fires it drew my interest to the impact of fire on ecosystems. Fires are a regular part of the ecology of the bush. When the fire burns the vegetation its minerals are returned to the soil with the ash. However, it is not just the vegetation that burns what about the organic matter in the soil itself? The temperatures reached in wild fires can be over 250°C at the surface of the soil and they can be up to 114°C in the top 2.5cm of soil. However, the temperature drops to 59-67°C at 7.5cm. What effect would this have on the mineral characteristics of the soil? I decided to investigate the effect of heating local soil samples within this temperature range and test the effect it had on the pH and selected minerals for which there were suitable tests.

Research question

What is the effect of temperature (70, 80, 90, 100, and 110°C) on the chemical properties of pH and mineral properties of phosphorus, nitrogen and potassium content of alfisol soil?

Prediction

The increased temperature will combust microbes and organic matter that regulate the bio-geochemicals of minerals such as phosphate, nitrates and potassium in soil for absorption by plants, thereby increasing the content of minerals in the burnt soil. The same combustion of organic matter will acidify the burnt soil.

Background Research:

Alifisols are soils where some of their minerals have been washed out. They have relatively high fertility though in Australia they are often poor in nitrogen and phosphorus. These soils have mainly formed under hardwood forest and have a subsurface of clays.

Nitrogen is present in proteins, vitamins and chlorophyll. Nitrogen allows for the development of vegetative activity of the plant and is absorbed by plants as nitrate ($N0_3^-$) which is derived from the mineralization of organic matter and the application of fertilizers. Moreover nitrates in water irrigate into soil. *(Hanna Technology - Nitrogen single test)*

Phosphorus occurs in natural waters as phosphate ($P0_4^{3-}$) ions. Phosphate introduction in soil is caused by waterways and irrigation systems from dams. Soil may be receptive of phosphorus via industry based runoff pollution. Phosphorus is essential as plants in the contribution to the formation of buds and roots. *(Hanna Technology - Phosphorus and phosphate analysis in water)* However, excessive amounts of phosphorus are the main cause of eutrophication, which is an abnormal and excessive growth of plants.

Potassium is present in tissues responsible for the growth of plants (primary and secondary meristems) *(Hanna Technology - Potassium in Agricultural examination).* Potassium regulates how much water is absorbed by the roots and in the control of cellular activity. Potassium helps safeguard plants to diseases. The problem of lack of potassium is frequent in alfisol soils.

Micro-organisms living in the soil produce complex carbohydrates that the plant uses for energy. Plant enzymes decompose large nutrient molecules, such as fulvic and humic acids, into smaller molecules for plant absorption. Beneficial fungus in the soil (mycorrhizae) act as a substantial secondary root system and help transport these synthesised substances to the plant roots. These biological factors are interdependent on an optimum pH of 6.5 *(Guide to Organics and Hydroponics in Gardening).*

Table 1: *Variables*

Variable type	**Identification**
Independent Variable	Temperature of oven regulated at 70°C, 80°C, 90°C, 100°C and 110°C
Dependent Variable	Concentration of mineral using Hanna Instruments Agriculture Test Kit
Controlled Variable	Soil samples were taken from the same site
	Duration of burning (24 hours)
	Origin of soil from one area locally
	Ratio of water to soil in sedimentation (120:960)
	Time allowed for soil particles to settle (24 hours)
	Soil dried before use. The water content may affect the pH and mineral content in measurement particularly of the unheated control.
	Mass of soil used (120g)
	Time for colour complex to development (30 seconds in mineral tests, 5 minutes for pH tests).
	Volume of extract used after sedimentation (2.5cm^3)
	Amount of universal indicator (3-5 drops)
	Mass of reagent used (pre-weighed sachets provided in the kits)
Uncontrolled Variable	The amount of natural sunlight received both before the soil was obtained and during the experiment. Soil areas exposed to sunlight may have more original minerals in soil, as opposed to soil sourced from areas covered by shade because of greater plant growth.
	Original mineral content in soil This will vary with the area and deepness in soil thought the sampling was consistent and the site carefully selected.
	Porosity this may affect the efficiency of mineral transfer
	Quantity of organic matter soil samples may have varied

Control Experiment: The control experiment incorporated into the design is a condition whereby the soil is sourced directly from the ground and tested for pH, phosphorus, nitrogen and potassium without introducing the independent variable of heat. This control will allow for the comparison between normal soil content and subsequent mineral content to increased heat exposure.

Materials

Table 2: *Apparatus required for experiment with associated quantity*

Quantity	Apparatus
1	Industrial Oven (110, 100, 90, 80, and 70 degrees C)
1	Electronic Scales +/- 0.001
1	Hanna Technology - **HI 3895** Agriculture Test Kit (Chemicals listed in table below) Colorimetric reference cards, transfer pipette, volumetric reference card, 4 test tubes.
1	Stopwatch
320	Alfisol Soil
5	Large Crucibles
1	500cm^3 beaker
1	1000cm^3 beaker
1	Protective oven mitts
1	Sharpee© Labelling Marker
1	Spatula
1	Spotting glass
1	5cm^3 micropipette
1	Pipette pump

Table 3: *Chemicals required for experiment with associated quantity*

Quantity	Chemical
5dm^3	Distilled Water
25	POTASSIUM test reagent - Tetrasodium salt dehydrate, lithium hydroxide monohydrate, sodium tetraphenyl borate
25	NITROGEN test reagent - Citric acid monohydrate, barium sulphate
25	PHOSPHORUS test reagent - Mixture of crystalline powders
50cm^3	Universal Indicator
100g	Barium Sulphate$_{(s)}$

Practical Safety and Risk Assessment
Assessment of risk and practical safety precautions are account for in the Risk Assessment plan
Refer to Appendix A - STUDENT ACTIVITY RISK ASSESSMENT and PRAC ORDER FORM

Method

Soil sample

The soil was obtained from an unmanaged forested area. To avoid any outside influence that could have affected the mineral content, the sample was taken in a zone with no neighbouring farmland and the sample was dug from the first 20cm of soil at least 20m from the track that gave access to the site. The site had no recent record of burning.

Heating

1. Preheat the industrial oven in practical set-up room by configuring to experimental temperature of 110 degrees C (or 100, 90, 80, 70°C)
2. Transfer measured mass of soil to individual crucible and note qualitative observations.
3. Wait until the oven has reached required temperature, then place the crucible in the oven.
4. Wait 24 hours for the soil to burn
5. Remove the crucible and note qualitative observations (porosity, granularity etc).

Five samples of soil were heated for each treatment. Three samples were kept unheated as a control.

pH measurement

1. Sample 4g soil and add it to appropriate test tube from agriculture test kit, fill with distilled water until the lower graduation mark is reached (2.5mL).
2. Add the content of the packet labelled HI 3895-pH reagent (inclusive of calcium chloride dehydrate or universal indicator and barium sulfate) to test tube from test kit.
3. Replace the test tube cap and shake the tube gently for 30 seconds. Use the stopwatch for precise time measurement
4. Allow the sample in test tube to stand for 5 minutes to ensure colour complex development
5. Compare the pH colour-card to the sample colour. Record sample pH. For optimum measurement, ensure light filtered into laboratory is maximised, hold colour card approximately 2 cm from sample for comparison against a uniform white background.

Estimating N, P, K levels

1. Zero the balance and add 120g soil sample to the beaker.
2. Use the ratio of soil to distilled water (225:1800 reduced to 120:960).
3. Allow soil to separate into components; organic matter, clay, silt etc. for 24 hours to ensure maximum separation undisturbed (the clearer the extract becomes, the better the results of the mineral test)
4. Use a pipette to extract 2.5mL of clear general soil extract and add it to a test tube. (do not transfer soil, avoid agitation of soil sediment, squeeze the bulb of the pipette prior to inserting into soil extract solution)
5. Add contents of specialised reagent for test (nitrogen - HI 3895-N, phosphorus -HI3895-P, potassium - HI3895-K)
6. Replace and secure the test tube cap on the apparatus. Shake the test tube gently for 30 seconds.
7. Allow the sample in test tube to stand for 30 seconds for colour complex development
8. Match the colour apparent in the sample to the reference colour card using a uniform white background and under uniform lighting.
12. Record qualitative observations, record relevant data.

Ensure safety equipment is worn (laboratory overcoat and safety spectacles)Ensure photographic evidence is recorded for qualitative observation.

Modifications to the method

Rocks were removed from the measured mass in crucibles in order to maximise the amount of soil content in each trial. Rocks do not assist in transfer of minerals.

More Universal indicator was added to some samples in order to produce evidence pH of soil.

The test tubes required shaking in order to react the reagents with the soil extract was approximate in the trials. This may have resulted in inconsistent measurements as reagents may not have associated with soil in these shaken more gently compared to those shaken more vigorously.

Table 4: *Tabulated raw data to show the levels of pH, nitrogen, phosphorus and potassium in soil after burning at varying temperatures - 70, 80, 90, 100, and 110°C*

Temperature / °C ±0.1°C		PH and mineral content of alfisol soil			
		pH	Nitrogen	Phosphorus	Potassium
Control	Trial 1	7.0	TRACE	TRACE	LOW
	Trial 2	6.0	TRACE	TRACE	MEDIUM
	Trial 3	7.0	TRACE	TRACE	MEDIUM
70	Trial 1	7.0	TRACE	TRACE	LOW
	Trial 2	7.0	TRACE	LOW	TRACE
	Trial 3	7.0	TRACE	TRACE	LOW
	Trial 4	7.0	TRACE	TRACE	TRACE
	Trial 5	7.0	TRACE	TRACE	TRACE
80	Trial 1	6.5	LOW	HIGH	HIGH
	Trial 2	6.5	LOW	LOW	HIGH
	Trial 3	6.5	LOW	LOW	HIGH
	Trial 4	6.5	LOW	MEDIUM	HIGH
	Trial 5	6.5	LOW	HIGH	MEDIUM
90	Trial 1	6.5	MEDIUM	TRACE	LOW
	Trial 2	6.5	MEDIUM	TRACE	LOW
	Trial 3	6.5	MEDIUM	TRACE	LOW
	Trial 4	6.5	MEDIUM	TRACE	LOW
	Trial 5	6.5	MEDIUM	TRACE	LOW
100	Trial 1	6.0	TRACE	LOW	MEDIUM
	Trial 2	6.0	LOW	LOW	MEDIUM
	Trial 3	6.0	LOW	TRACE	MEDIUM
	Trial 4	6.0	TRACE	TRACE	MEDIUM
	Trial 5	6.0	TRACE	TRACE	MEDIUM
110	Trial 1	6.0	TRACE	TRACE	HIGH
	Trial 2	6.0	TRACE	TRACE	HIGH
	Trial 3	6.0	LOW	TRACE	HIGH
	Trial 4	6.0	LOW	TRACE	HIGH
	Trial 5	6.0	LOW	TRACE	HIGH

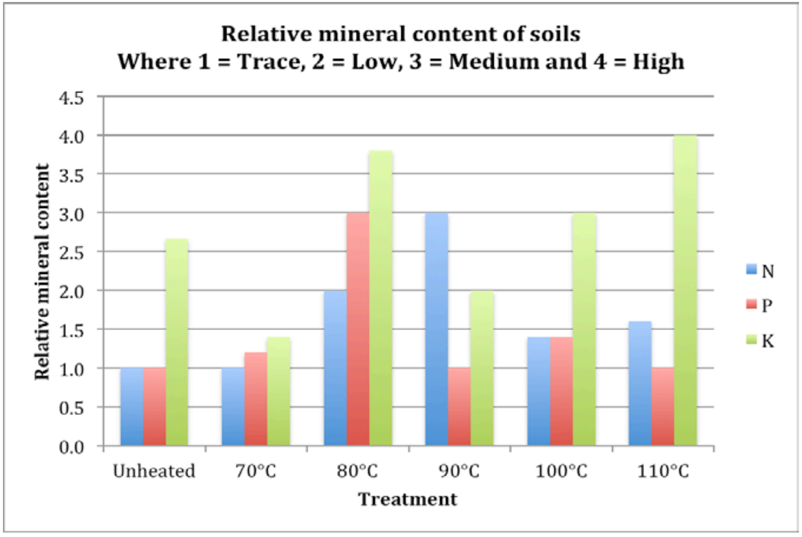
Table 5: *Observations noted in the duration of the experimentation process with associated explanation and implication on results if applicable.*

Observation	Explanation/ Implication
Grey soil after burning	Discolouration caused by absence of organic matter regulating soil content - suggests increase in silt and clay levels which limit the oxygen and carbon dioxide emission and absorption by soil.
Colour change was evident immediately - did not have to wait	The colour complex developed immediately in most trials - except nitrogen tests.
Sunlight changed content	During sedimentation, the 1000cm^3 beaker was placed in the sun for the 90°C trial. This may have influenced the process of mineral separation in soil, as soil absorbs sunlight.
Different amounts of sediment	Vary levels of floating dead organic matter, and clay, silt etc on bottom of beaker. This may be the result of the source of soil - increased level of organic matter at levels of soil near the surface, however deeper down, the soil may contain more clay and rocks etc.
Some organic matter transferred in trial	The method was to leave organic matter undisturbed when transferring liquid soil extract, however, the micropipette had to penetrate the surface and matter adhered to/ transferred by the pipette to the test tube.

Table 7: *The averaged results of pH and the overall results of mineral tests at varying temperatures*

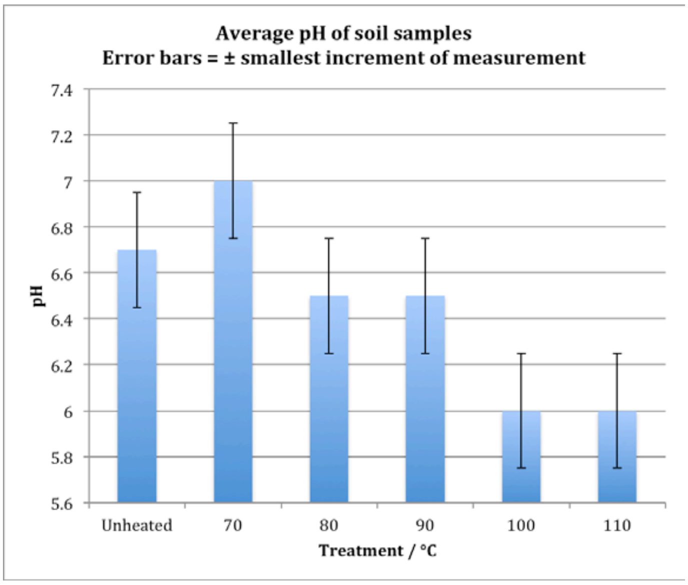
Temperature / °C ±0.1	pH and minerals			
	pH	Nitrogen	Phosphorus	Potassium
Unheated	6.7	TRACE	TRACE	MEDIUM
70	7.0	TRACE	TRACE	TRACE
80	6.5	LOW	HIGH	HIGH
90	6.5	MEDIUM	TRACE	LOW
100	6.0	TRACE	TRACE	MEDIUM
110	6.0	LOW	TRACE	HIGH

Graphs

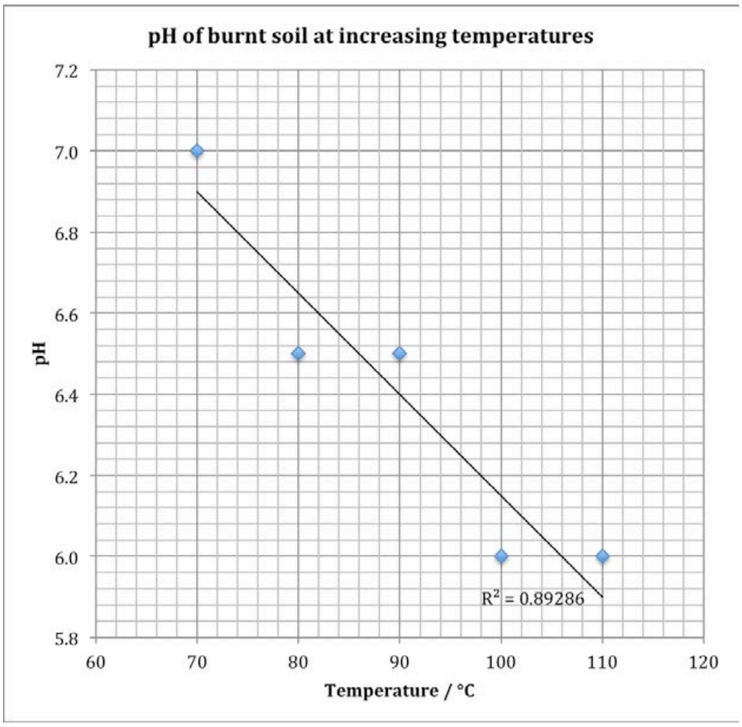


The graph shows the averaged results obtained from the experiment in testing for minerals - phosphorus, nitrogen and potassium. The graph depicts the mineral content as a result of increased temperature exposure of soil as well as the control (unheated). There appears to be a trend in increasing potassium levels as the temperature increases above 90°C, however there is no specific pattern for other tested minerals of nitrogen and phosphorus. It appears the optimum temperature to produce the highest content of phosphorus is 80°C, and the optimum for nitrogen is 90°C.

Page 5



This graph shows the average pH values for the soil samples treated at different temperatures along with the control sample (unheated) for comparison. Overall there appears to be a progressive fall in pH levels for the heated samples though there is a bit of variation between the unheated sample and the one heated to 70°C.



The graph shows the averages results obtained from the experiment in testing pH of burnt soil. The soil was exposed to increasing temperatures and subsequently tested for a decrease (increasingly acidic) pH. The results show that as temperature increases, the pH decreases accordingly - there is a correlation between increasing temperature and acidity of soil. The linear trend line suggests this correlation. This correlation is supported by the coefficient of determination (R^2 value) which is equal to 0.8929. This value is high indicating a good fit with the trend line and it suggests a negative correlation.

Conclusion

The data obtained supports the idea that the pH of the soil becomes more acidic at higher temperatures. The data suggests that there is an increase in the mineral content with heating of alfisol soils.

Table 7, averages of the raw data, demonstrates the increase of temperature that is directly proportional to an increase in mineral content. At temperatures of 110°C, the potassium levels are highest. However, this trend is not present in all mineral compounds. Nitrate compounds in burnt soil are highest at 90°C. Phosphate molecules in soil are highest in at 80°C. This suggests that at certain temperatures, the mineral content in soils for varying minerals changes, both in quantity and type. The general increase in mineral content is presumed to be a result of the microbe combustion in the soil. Microbes and organic matter store and regulate minerals such as nitrates and phosphates in the soil - in addition to absorption by plants and other organisms. When the soil is exposed to heat, the change in temperature combusts the organic matter, releasing the mineral and resulting in their increased levels. However, this does not suggest that plants are able to use these enriched resources. Naturally decomposer organisms, such as worms, are able to produce organic compounds and release minerals for plants. Without these decomposers to maintain the cycle, the plants will only have a certain store of minerals. Moreover, despite the increased availability of minerals, plants require other factors of soil such as porosity, which determines water retention. Soil that is subjected to extreme temperatures loses the ability to hold water for plants and organisms - which is why burnt lands are unable to sustain plant growth until revived naturally. However, an application of this is that burnt soil may be mixed in with mineral deficient soil in order to boost mineral levels in the soil for plants. This would enhance the soil chemical properties and aid growth of plants. Furthermore, alfisol soils are typically naturally deficient in minerals such as potassium and nitrogen in Australian regions.

The third graph depicts the change in pH as a result of increasing temperature exposure. There is a good correlation between increasing temperature and decreasing pH. This is supported by the high coefficient of determination, R^2 value = 0.8929. Nitrogen minerals exist as nitrates in the soil ($N0_3^-$). Since the increase in temperature increases the quantity of nitrates in the soil, the soil will acidify as a result. This is the same in phosphates (Holleman , A - Inorganic Chemistry 2001). It can be predicted that at temperatures exceeding 110°C, it pH will continue to become increasingly acidic - demonstrated by the consistent linear trend line until all the organic matter is combusted.

Solubility of minerals in soil varies with the pH of the soil. Most minerals are readily available at a pH of 6 to 7. Phosphorus is more available at pH 6.5 and below pH 5 aluminium, iron and manganese become more soluble. Aluminum is toxic for many plant species and it is particularly rich in alfisols. So the observed drop in pH with heating could result in some valuable minerals becoming more accessible to begin with but a strong drop in pH could make the soil less fertile.

Reliability

The data collected is reliable with a number of minor omissions. The alfisol soil, which is typical soil family found in most areas of Australia, is known for a range of physical properties. The results cannot be generalised to all soils as the test conducted on the soil obtained may contain mineral levels different to those of an alfisol soil found in Western Australia. Moreover, it was unreliable to the extent the pH tests are variable in the controls. The water content of the controls may have influenced these results. In the heated samples the water evaporated off.

The original organic matter in the soil, which influence the mineral content, as well as the plant concentration in the area of source was not recorded. This would be an indication of the general nature of the results to areas containing similar quantities of organic matter. Moreover, the level of sunlight received by the areas where the soil was sampled was not controlled. The intensity of the sunlight will determine the rate of photosynthesis of plants. If the soil is in a particularly shady area, then the photosynthetic activity of plants would be lower than that of plants constantly receiving of sunlight. This would result in a lower biomass of plants and less organic matter in the soil. A decreased level of photosynthesis could result in the mineral content of the test soil being lower.

The experiment repeated trials for the samples which helps to reveal the reliability of the data in consistency between trials. The uncertainty associated with the reference cards means that the content of minerals in the soil solution could potentially be half a grade higher or half a grade lower of that identified. Moreover, error in human visual analysis, is significant. The reference cards require an observation by the experimenter to a standardised measurement, whereas a measuring probe like a colorimeter may be able to analyse the concentration more objectively.

Evaluation of the method
There were a number of systematic and random errors associated with the uncertainty of the data which is a limitation to the results.

A systematic error associated with the data is in reference to the colorimetric indications cards. These apparatus are non-numerical - and rely on a comparison between the solution colour as a result of the reagent, and a standardised TRACE, LOW, MEDIUM or HIGH reference on the card. This is a limitation to the design whereby the data, excluding pH, cannot be converted into numerical data. Therefore the uncertainty related to the data is half of the smallest increment - for example between HIGH and MEDIUM. This is a large uncertainty as it suggests there may be a different concentration value of the mineral in the solution. A similar problem occurred with the pH tests. This method requires universal indicator in order to colour the soil and compare this subsequent colour to a pH reference chart.

A random error is that the method stated: *"Allow soil to separate into components; organic matter, clay, silt, mineral content etc., for 24 hours to ensure maximum separation undisturbed (the clearer the extract becomes, the better the results of the mineral test)."* However, each test was not allowed 24 hours (due to experimentation time restraints), which resulted in a yellow coloured extract, as opposed to a translucent one. This suggests that the results obtained may not have been the optimum indication of mineral content in the burnt soil. Moreover, the time for sedimentation was a maximum of 24 hours. The soil used does not give an indication of the duration of the sedimentation process needed, and therefore the range of time is 30 minutes to 24 hours. It was assumed the 24 hours would be suitable for a complete result.

The reagents used as indicators of the minerals were prepared in sachets that were opened and added to the soil aqueous extract. However, the entire quantity was not added in each case due to the difficulty of releasing the chemicals. This may result in a lighter colour of the solution, which would demonstrate a qualitative comparison that does not necessarily represent the actual quantity of mineral in the sample.

Another random error is that the oven, which controls the temperature of heating, was temporarily opened by other students and the temperature decreased from 110 to 97°C. This is an inconsistent heating process and the trials will require a repeat to ensure accurate results were opened. The temperature drop of 13°C temperature may have had and affect on the experiment.

Modifications to Experiment
To increase the accuracy of results, there is a professional version of the HI 3895 test kit used to test mineral content in the soil in this experiment. HI 3896 uses a similar methodology to the HI 3895 agriculture test kit, however uses colour compactors and assigns numerical values to the colour comparison. This will provide a significantly more measureable basis to the results.

Alternatively an ultraviolet-visible light spectrophotometer may be used to test the unknown concentration compared with a calibration curve created using standard solutions of diluted phosphate stock solution. The spectrophotometer will provide a more accurate measurement compared to the reference card. This may be applicable to other minerals such as potassium compounds and nitrate compounds.

Hanna instruments, the company that manufactured the agriculture test kit used to test the content of minerals and pH in the soil, additionally produces a product called a phosphate checker. The instrument uses a silicon photocell that works similar to a ultraviolet-visible spectrophotometer, however this tests for orthophosphates only using the reagents and no calibration is required to determine the concentration. The apparatus measurement ranges from 0.00 to 2.50ppm with an uncertainty of 4.0%. The apparatus is manufactured for nitrates and potassium compounds, in addition to phosphates.

In reference to the pH tests, a pH probe may be used to determine a more accurate measurement of the pH of the soil. The method for using this apparatus is extracting a specific mass of soil and adding distilled water. This solution may be filtered using filter paper and funnel. The pH probe, after calibrating in electrolytes and cleaning in distilled water, will measure the pH of the solution accurately.

A modification to the experiment could be the manipulating the independent variable as time rather than temperature. The experiment has demonstrated that temperature change will influence the mineral content in soil, however a derivative of the experiment could investigate the effect of time duration of burning. This would provide a more ecologically valid representation of bush fire examples - uncontrolled and controlled fires.

A further variation of the experiment may investigate the effect of lower temperatures, since the higher temperatures combusts all organic matter/large majority of organic matter, lower temperatures that will destroy only some of the organic matter.

Table 9: *Summary of modifications to experimental design*

Modification	Explanation
UV-Vis Spectrophotometer	Accurate measure the concentration of phosphate ions in soil extracts
Phosphate checker	Works in similar effect to UV-Vis apparatus, does not require calibration curve - measures phosphate concentration directly.
HI 3896	Precise agriculture test kit compared to HI 3895 - assigns numerical values
Lower temperatures	Maintain higher content of minerals with regulation by remaining organic matter.
Duration of heating	Change the independent to time -> better reflects the ecological factor of fire and soil.
pH probe	Used to measure the pH of the solution - filter soil extract and measure pH
Control sample water content	Air dry the control soil at room temperature

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Name:		Date req'd:	Est finish date
Supervising Teacher:	Class Name: 11C	Period:	Location: EO21

Activity Title: The effect of heat on the physical and chemistry mineral properties in soil

Hypothesis being tested: The increased temperature will combust microbes and organic matter that regulate the bio-geochemicals of minerals such as phosphate, nitrates and potassium in soil for absorption by plants, thereby increasing the content of minerals in the burnt soil. The same combustion of organic matter will acidify the burnt soil.

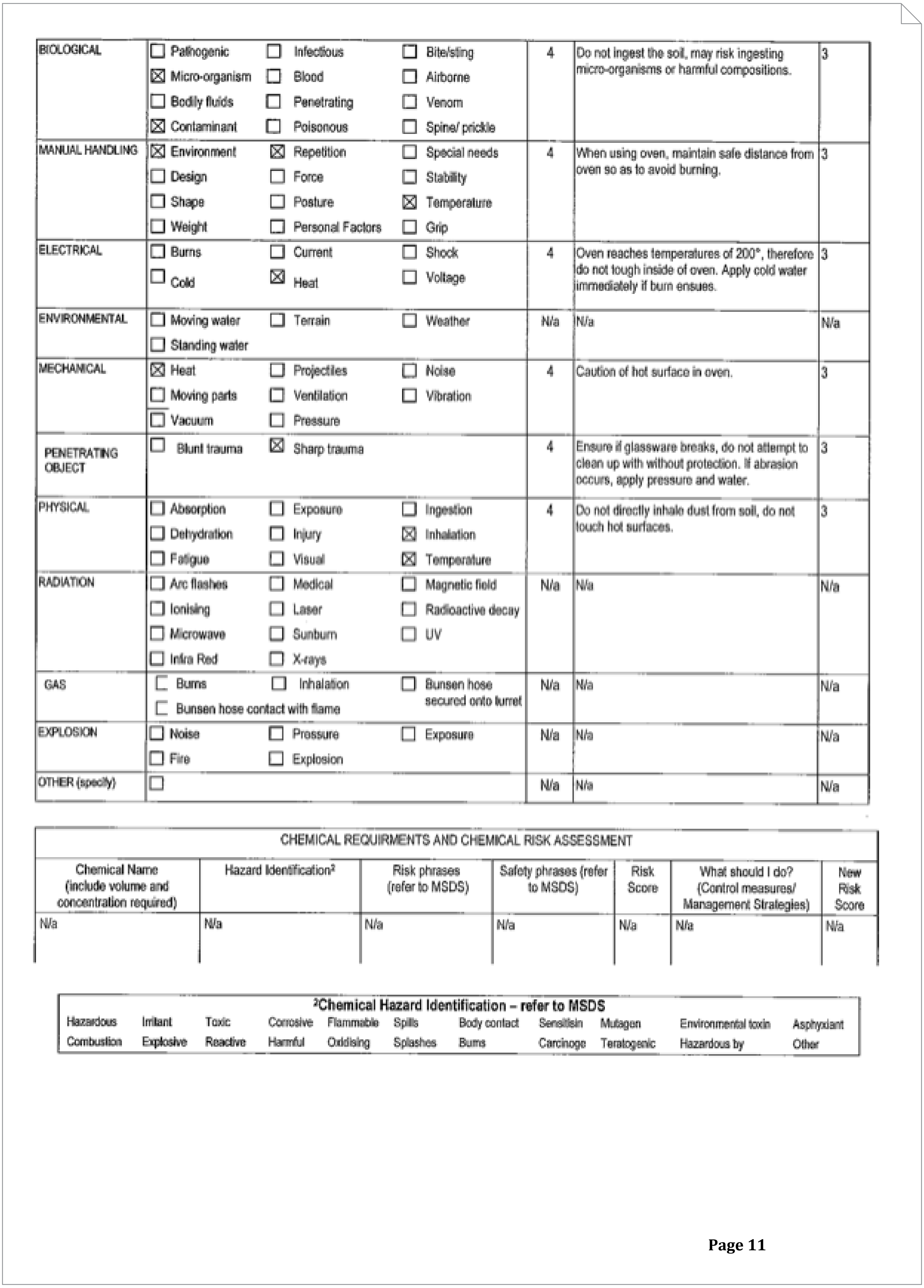
Materials/ Equipment requested:

Quantity	**Apparatus**
1	Industrial Oven (110, 100, 90, 80, and 70 degrees C)
1	Electronic Scales +/- 0.001
1	Hanna Technology - **HI 3895** Agriculture Test Kit (Chemicals listed in table below) Colorimetric reference cards, transfer pipette, volumetric reference card, 4 test tubes.
1	Stopwatch
320	Alfisol Soil
5	Large Crucibles
1	500cm^3 beaker
1	1000cm^3 beaker
1	Protective oven mitts
1	Sharpee© Labelling Marker
1	Spatula
1	Spotting glass
1	5cm^3 micropipette
1	Pipette pump
Quantity	**Chemical**
5dm^3	Distilled Water
25	POTASSIUM test reagent - Tetrasodium salt dehydrate, lithium hydroxide monohydrate, sodium tetraphenyl borate
25	NITROGEN test reagent – Citric acid monohydrate, barium sulphate
25	PHOSPHORUS test reagent – Mixture of crystalline powders
50cm^3	Universal Indicator
100g	Barium Sulphate$_{(s)}$

HAZARD IDENTIFICATION		RISK EVALUATION		
What could cause harm? (Risk Source)	What type of risk is associated with this activity? (Hazard Identification)	Risk Score	What should I do? Control Measures and/or Management Strategies	New Risk Score[1]
STUDENT CAPABILITY	☒ Experienced ☐ Intermediate ☐ Novice	n/a	Knowledge of equipment, laboratory safety standards and behaviour.	n/a
CLASSROOM	☐ Contact ☐ Noise ☐ Slip ☐ Moving parts ☒ Fall ☐ Posture ☒ Collision ☐ Sharps ☐ Impact	3	Pay attention to surrounding, ensure that work station is clean and prepared.	2
SURFACE	☐ Carpet ☐ Grass ☒ Synthetic ☐ Cliff/slope ☐ Padded ☐ Wood ☒ Concrete ☐ Slippery ☐ Uneven	4	Be careful when on concrete and moving around apparatus (glass jars, comparators) increase it breaks.	3

[1]**Risk Scores – 9-10 Extreme Risk.** Do not proceed. Substitute or eliminate. **7-8 High Risk:** Principal authorisation required. Substitute or eliminate. **5-6 Moderate Risk:** HOD/HOF signature required. Consider implementing further risk controls **2-4 Low** Teacher signature required.

Page 10



BIOLOGICAL	☐ Pathogenic ☒ Micro-organism ☐ Bodily fluids ☒ Contaminant	☐ Infectious ☐ Blood ☐ Penetrating ☐ Poisonous	☐ Bite/sting ☐ Airborne ☐ Venom ☐ Spine/ prickle	4	Do not ingest the soil, may risk ingesting micro-organisms or harmful compositions.	3
MANUAL HANDLING	☒ Environment ☐ Design ☐ Shape ☐ Weight	☒ Repetition ☐ Force ☐ Posture ☐ Personal Factors	☐ Special needs ☐ Stability ☒ Temperature ☐ Grip	4	When using oven, maintain safe distance from oven so as to avoid burning.	3
ELECTRICAL	☐ Burns ☐ Cold	☐ Current ☒ Heat	☐ Shock ☐ Voltage	4	Oven reaches temperatures of 200°, therefore do not tough inside of oven. Apply cold water immediately if burn ensues.	3
ENVIRONMENTAL	☐ Moving water ☐ Standing water	☐ Terrain	☐ Weather	N/a	N/a	N/a
MECHANICAL	☒ Heat ☐ Moving parts ☐ Vacuum	☐ Projectiles ☐ Ventilation ☐ Pressure	☐ Noise ☐ Vibration	4	Caution of hot surface in oven.	3
PENETRATING OBJECT	☐ Blunt trauma	☒ Sharp trauma		4	Ensure if glassware breaks, do not attempt to clean up with without protection. If abrasion occurs, apply pressure and water.	3
PHYSICAL	☐ Absorption ☐ Dehydration ☐ Fatigue	☐ Exposure ☐ Injury ☐ Visual	☐ Ingestion ☒ Inhalation ☒ Temperature	4	Do not directly inhale dust from soil, do not touch hot surfaces.	3
RADIATION	☐ Arc flashes ☐ Ionising ☐ Microwave ☐ Infra Red	☐ Medical ☐ Laser ☐ Sunburn ☐ X-rays	☐ Magnetic field ☐ Radioactive decay ☐ UV	N/a	N/a	N/a
GAS	☐ Burns ☐ Bunsen hose contact with flame	☐ Inhalation	☐ Bunsen hose secured onto turret	N/a	N/a	N/a
EXPLOSION	☐ Noise ☐ Fire	☐ Pressure ☐ Explosion	☐ Exposure	N/a	N/a	N/a
OTHER (specify)	☐			N/a	N/a	N/a

CHEMICAL REQUIRMENTS AND CHEMICAL RISK ASSESSMENT

Chemical Name (include volume and concentration required)	Hazard Identification[2]	Risk phrases (refer to MSDS)	Safety phrases (refer to MSDS)	Risk Score	What should I do? (Control measures/ Management Strategies)	New Risk Score
N/a	N/a	N/a	N/a	N/a	N/a	N/a

[2]Chemical Hazard Identification – refer to MSDS

Hazardous	Irritant	Toxic	Corrosive	Flammable	Spills	Body contact	Sensitisin	Mutagen	Environmental toxin	Asphyxiant
Combustion	Explosive	Reactive	Harmful	Oxidising	Splashes	Burns	Carcinoge	Teratogenic	Hazardous by	Other