Components of Wood Ash

Overview

After burning of wood, the ash that remains seems to be an inert and useless substance. However, ash is composed of several compounds, which can be understood to originate from (i) the composition of original wood and (ii) the process of burning. This unit is focused at understanding wood ash as a substance and its chemical properties.

The unit has five tasks. In first task, students go through a series of questions meant to bring their attention to the grey colour of the ash, which could be due to combination of some white and some black particles. Here they need to think what kind of substances burn to give white particles and what material will give black particles on combustion. The teacher may also keep in mind that the proportion of white and black components in an ash sample would also depend upon if wood was allowed to burn completely in sufficient supply of air (when you get lighter or whitish ash), or if there was incomplete combustion (in which case you get blackish ash).

The second task involves passing water through ash and showing that ash has some component which easily dissolves in water and the solution obtained has properties different from water. In the third part, the solid residue obtained after dissolving away the water soluble component is analyzed. Lemon juice is passed through the solid ash residue, some of which further dissolves in the juice. While ash residue does dissolve in lime juice, not all of it dissolves. Some residue is still left which does not have all properties similar to the initial ash sample.

In the fourth task, water extract of ash from task 2 is used to see if it can clean oily cloth, and prevent bacterial growth in milk. Then in task 5, students look at what all they have learned in the previous four tasks. This summarization prepares them to learn further about wood ash as a material and also the combustion process.

Minimum time required: 4 periods of 40 minutes each

Type of Learning Unit: Laboratory

Links to the curriculum

NCERT CLASS 7	NCERT CLASS 8	NCERT CLASS 10
Acids, bases and salts	Combustion and flame	Chemical reactions and equations, metals and non- metals

Learning Objectives

1. To understand that wood ash is a mixture of multiple substances with different colours and properties.
2. To identify the acidic/basic/neutral nature of different (black and white) components of wood ash.
3. To understand that the white and black substances in ash might be indicating metallic compounds and carbonaceous matter, respectively.
4. To learn a simple technique of separating substances from a mixture based on different solubilities of different components.
5. To gather evidences for anti-microbial and detergent properties of some components of ash.
6. To develop some insights about the science of combustion for wood and similar materials (that how substances of different colours burn to give grey ash).

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Introduction

Ash is a common substance we see around us. It is obtained by burning wood, cattle dung cakes, incense sticks, coconut shells, natural fibers etc. It is grayish in color. It is generally defined as the solid residue that remains after burning a material, while some products of combustion escape as gases. Ash, as we know, is used in a large number of applications such as for pest control in agricultural soils, and to control bacterial growth in rotting materials, cleaning utensils, etc. Can we also use ash for washing clothes?

We may want to ask if wood ash is a single substance or it has many substances in it? Different colours (white, black and grey) and different shades in ash indicates it most probably has multiple substances in it. Separations of substances from a mixture has been one of the very important processes for chemists to purify or to obtain "Pure" substances. The extracted pure substances are useful in production of medicines, household substances, or raw materials for industries.

In this unit, we will try to explore components of wood ash and separate them on the basis of their solubility in water and lemon juice.

Materials Required

1. Wood Ash. Make sure the ash collected is not contaminated with soil or any other unburnt matter (like food matter), otherwise the original properties of ash will not be observed in the tasks. It should also not be wet.
2. Juice of 3-5 Lemons, squeezed and filtered through a strainer
3. Funnel and filter paper (or a cloth and a tea-strainer)
4. 4-5 beakers (100 or 250 mL) or any other similar containers
5. Glass rod, or spoon, or spatula
6. Test tubes, test tube stand
7. Litmus paper (red and blue), and turmeric powder
8. A piece of cloth having oil stains

Task 1: Let us think a bit

> Questions in this task are meant to consolidate students' prior knowledge and intuitive understanding about ash. Hence, the students are not expected to arrive at the correct answers. These questions also require making predictions, and visualizations of unknown situation, which prepares students to learn better from tasks ahead.
>
> In fact, if the students' predictions turn out to be wrong during experiments, then the learning can be even deeper than if they were correct. Thus, try not to make students get the correct answers, but do insist that students write their answers here. Encourage the students to discuss the possible answers in groups of 3-4 students.

Q1. Can you list some ways in which wood ash is used in your homes or surroundings?

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> Some of the uses of ash are given in introduction above. Encourage students to write some other uses that they have seen, or more details of above uses if they have seen these in their surroundings. Some such examples can be making soap, use as fertilizer.

Q2. What do you think ash is made of?

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> Ash is the end product of combustion of matter derived from living beings (plants, animals, dung). One common answer observed is: carbon or carbonaceous matter. Some may say silica or other minerals also. While ash is made of mostly minerals, but sometimes it contains some amount of partially burnt carbonaceous material also.

Q3. Do you think ash is soluble in water? Give reason for your answer.

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> Students may answer YES / NO. Encourage them to think whether they can recollect incidences such as cleaning utensils, where ash is mixed with water and if it dissolves completely or some solids remain. Students must write this (based on their past experience or knowledge about ash) without trying it out.

Q4. If water is mixed with ash, would the water filtrate be acidic, basic, or remain neutral?

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> Encourage students to write any answer. Discuss with them what components they think might be present in the mixture that would make it acidic/basic/neutral. One common answer we have received is that ash contains a lot of carbon and therefore it would be acidic. At a later stage (after doing this unit), students may try dissolving carbon (from soot of a flame, or carbon rods obtained from batteries) in water and checking it.

Ash is gray in color. To understand this colour we should understand that wood or plant parts, contain different types of components, such as starch, silica, some metal salts, some volatile compounds. If we take the following white coloured substances and observe changes in their colour on burning:

(i) Salt and lime (calcium oxide), when burned, remain white.

(ii) Camphor when burned completely disappears leaving no residue behind.

(iii) Sugar on burning produces a black coloured charred substance. If the burning is continued longer, then eventually the black char may also disappear completely.

(iv) white sand (which most consists of silica) doesn't show any change on heating or burning.

Q5. If a mixture of salt, sugar, camphor and white sand is taken and burnt, what would be the color of the ash obtained?

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> Here, encourage students to recollect if they have seen these substances being kept on heat or fire, or they can try to reason out the possible answers with the reasons for them.

Q6. What kind of particles do you observe in the ash? Why do you think ash is grey in color?

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(Fine grey powder, hard chunks of particles, black soft pieces of burnt wood) Help students to think about the origins of the different components present in ash that would be responsible for the color.

Task 2: Ash & water

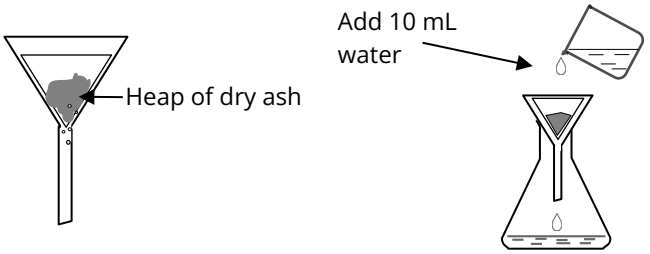
Before beginning this task, teacher may need to demonstrate to students use of some labwares: pouring water from one beaker/test tube/conical flask to another; stirring using a glass rod; folding and setting a filter paper in a funnel (if needed by very slightly wetting it); pouring in a funnel from the sides or pouring gently through glass rod, using a litmus paper/ or turmeric powder to check acidic/basic nature of substances.

In this task, we will see if ash dissolves in water. But before that note the place from where the ash was collected. Source of ash: _____

Do the following task in groups of 3-4 students. Take about 5 g (or a table spoonful) of powdery part of ash (and avoid the big pieces from the ash).

Here either every group of students can weigh 5 g of ash. The teacher can alternatively weigh 5 g and keep on watch glass, and students can take approximately same amount by visual estimation.

Step 1: Fold a filter paper and set it in a funnel (instead of filter paper, a clean white thick cloth kept on a tea strainer can also be used).
Step 2: Set this funnel/strainer on an empty beaker (or conical flask). Add 5 g of ash in the funnel.
Step 3: Mark the level of ash in the funnel for later comparison.
Step 4: Slowly add about 10 mL of water.



Q1. Was water completely absorbed by the ash or did some of it come down the funnel? If sand was kept instead of ash, would sand also absorb the same amount of water?

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This question is to bring to attention of students that ash absorbs some amount of water (typically 5-10 mL for 5 g ash) before some water will start coming down the funnel. This is a very important property of ash (and of some of its component chemical substances). It involves both wetting of ash particles on surface as well as formation of hydrated compounds, which is a very important phenomena in the chemical world.

Q2. Do you think some part of the ash has dissolved in water? On what basis did you answer this question?

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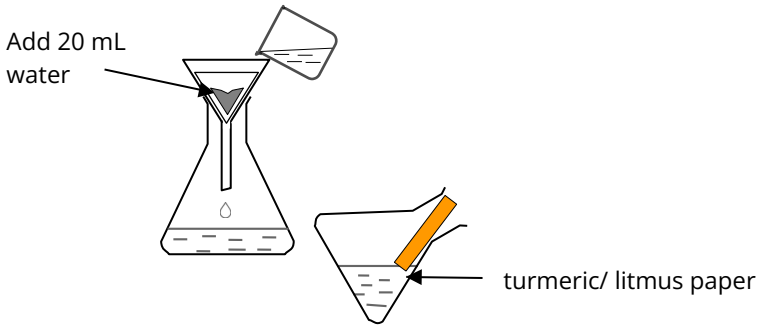
Yes, some part of ash dissolves in water. They may try to seek evidence for this by checking if there is change in the volume of ash after adding water, although this is not a confirmatory evidence.

Step 5: Slowly pour another 20 mL water over the ash in the funnel. This time, some water will start collecting in the beaker under the funnel.



Step 6: Use litmus/turmeric paper to check if the water filtrate collected under the funnel is acidic/basic/neutral.

Q3. Can you tell if anything from the ash has dissolved in water? If yes, what is the chemical nature of this water soluble substance in ash?

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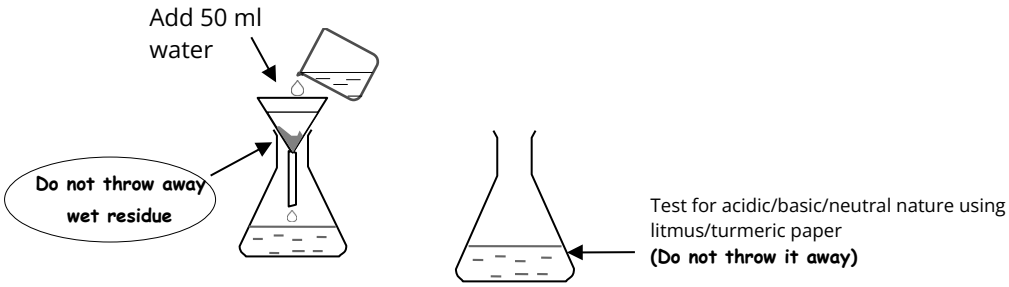
Red Litmus paper may turn blue, indicates that some alkaline substance has dissolved in water.

To check chemical nature using turmeric, add half spatula of turmeric powder to the test tube containing about 3-4 mL of filtrate. Shake it well and keep it for 1-2 min. The colour change may take some time (few minutes). Yellow turmeric turns red indicating alkaline nature of the solution.

Step 7: Remove the beaker/container containing the filtrate, and put another beaker/container under the funnel/strainer. Add 50 mL water to the funnel, stir the ash gently with a glass rod/spoon (should not tear the wet filter paper) and collect the filtrate. Repeat this step by adding another 50 mL of water. Check this filtrate with litmus/turmeric._____



Q4. Is something still dissolving from the ash? Would all the ash dissolve in water?

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Yes, some part of ash may dissolves in excess water; but entire ash will not dissolve in water since it

contains some water insoluble components.

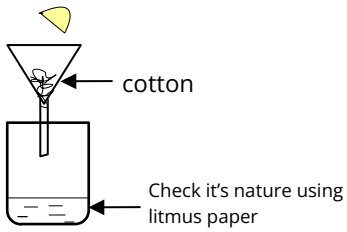
Step 8: If you feel more water needs to be added, add the water, let it filter and let the residue in funnel settle down.

Note: Do not throw the ash filtrate obtained in the above task. You will need it for further tasks.

Preparing for Task 4: Before you move to task 3, it will be better to do the preparation on (instructions given under Task 4) one day before you are planning to do Task 4.

Task 3: Ash residue & Lemon juice

Step 1: Squeeze some lemons and strain the juice through a tea strainer or filter it through cotton. Check if this juice is acidic, basic or neutral.



Q1. What observation is expected when lemon juice is added to the filtrate? What is expected when the juice is added to the solid remaining in the funnel?

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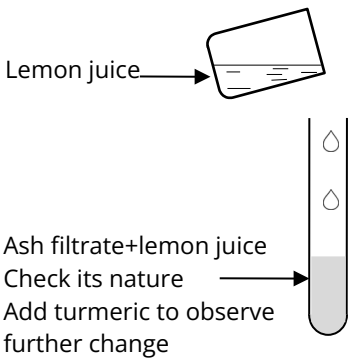
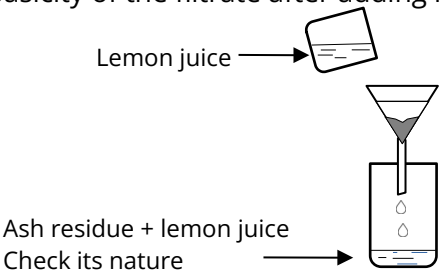
Here students should predict what they expect based on the acidic/basic/neutral property of the lemon juice before testing it.

Step 2: Take some ash filtrate in a test tube, add some lemon juice and note down the observations. Add some turmeric and see if there is change in acidity/basicity of the filtrate after adding lemon juice.





Step 3: Take the funnel containing the residual ash from task 2 and put another empty beaker under the funnel. Add lemon juice to the solid in funnel. Note any changes you observe (in colour, texture, any gases evolved, smell, heat) and what does this indicate.

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Step 4: Check if the filtrate collecting in beaker below is acidic, basic or neutral.

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> If the soluble alkaline substances aren't completely removed through water, then initially the filtrate might be neutral or even alkaline in nature. You may direct student's attention to this observations that on adding acid from the top, you are getting a base below the funnel. Further addition of lemon juice may retain acidic nature in the filtrate.

Q2. Is any part of ash dissolving in this lemon juice?

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> Yes, with evolution of gas some part of ash might be dissolving in the lemon juice. Students may seek evidence for this by checking whether the amount of ash residue in the funnel is decreasing or remaining the same on adding the lemon juice.

Q3. With which of the following substances, would you observe the similar effect as observed on ash with lemon juice: table salt, washing soda, sand, carbon, chalk powder?

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> Ash gives effervescence with lemon Juice. Such an action is also observed with lemon juice with washing soda or chalk powder. If students have not observed these substances interacting with lemon juice, teacher can try to demonstrate these reactions. Writing chemical equations for these reactions may be avoided at this stage.

Step 5: Add about 20 mL more of lemon juice to the funnel. Keep adding the juice slowly and keep stirring till you observe no further dissolution/change taking place in remaining solid.

Step 6: Note the colour and texture of the solid remaining in funnel.

Q4. Is the solid looking different now than the original ash taken. What does this change tell about the components that dissolved in water/lime juice?

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> Here students may observe the colour of the residue. It would be looking more black/darker than the initial ash taken. They may also observe that the residue has much more harder particles left, while the initial ash was softer. This indicates that the ash components that dissolved in water and juice were white or having light colour shades, and also were finer or softer particles. Some students may also think that the residue is a new product formed from reaction of ash with lemon juice. Teacher may ask them if they can recognize particles which were present before adding the lime juice and present now also.

Q5. Has the amount of solid in funnel decreased after adding the lemon juice?

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Q6. Can we obtain the dissolved components (in water and in lemon juice) from the filtrate back in their solid state? How?

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> Yes. Dissolved component in water can be obtained in solid state by process of evaporation of water (they may be obtained as their hydrated forms). For lemon juice it is not possible to get the original substances, as some reaction may have taken place with the acid.

Task 4: Ash Filtrate & Its Uses

> **NOTE:** For this task, use boiled and cooled milk. Also check the pH of the filtrate and milk before mixing them separately and also after mixing them.

First day: Take about 5 mL milk each in two separate test tubes. In one of them, add 3 - 4 mL of the ash filtrate collected in **Task 2.** Keep the other test tube as a reference. Cover the two test tubes with aluminium foil/paper and keep them aside for about 10 hours.

Q1. Predict what will happen to the milk in the two test tubes when you leave them for few hours?

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Second Day: Check the two test tubes next day.

Q2. What differences do you see in the two test tubes? What effect did ash-water filtrate have on the milk?

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> Alkaline substances of ash filtrate retard the growth of bacteria and hence delay the spoilage of milk. However, this depends on the volumes of milk and of the filtrate mixed, temperature in the room, etc. Note that this should **not** be presented as a method of milk preservation because ash filtrate may contain some heavy metal salts also which may not make milk safe for human consumption.

Cleaning Oil spots: Take a small piece of cloth and put 2-3 drops of cooking oil on it. Then dip this cloth in the ash filtrate and see if you can remove the oil stain from the cloth.

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Task 5: What have we learnt?

Q3. Based on tasks 2-4, which of the following statement is correct. Give reasons for the incorrect statements being wrong.

- Ash consists of a single substance, which slowly dissolves in water or lemon juice.

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> Wrong. Ash consist of more than one substance since part of ash dissolves in water and some part of the residue left behind dissolves in lemon juice.

- Ash consists of two components, one soluble in water and other soluble in lemon juice.

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> Wrong. Ash consist of more than two substances since part of ash dissolves in water and some part of the residue left behind dissolves in lemon juice. Further, still some undissolved part of ash remains on the filter paper.

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- Ash consists of three components, one soluble in water, one soluble in lemon juice, and one that is not soluble in any of the two.

Correct.

- Ash consists of acidic substances.

No. Red litmus turns Blue

- Ash consists of alkaline substances.

Yes. Red litmus turns Blue.

- Ash contains two kind of basic substances, one soluble in water, and one soluble in acids.

Yes.

- Ash contains very hard particles, which do not dissolve in water, acids or bases.

Yes. Students have already tried dissolving in water and acids, and since the ash itself is alkaline, it also shows that the hard particles do not dissolve in weak bases. However, we can not make any conclusions here if these will dissolve in hard bases or not.

Q4. Based on above observation, was any foul smelling gas or an odour less gas evolved?

No foul smelling gas was detected but an odourless gas was evolved. Students may think of colourless gas to be CO_2 or H_2. On can test for absence of hydrogen by trying to bring a burning match stick to see if it is flammable.
Teacher can also discuss, if the observations in this unit indicate that the ash was just element carbon (as many people thought)? Teacher can also try to bring carbon black or graphite and indicate that carbon does not show the properties which ash exhibited.

Q5. Now that you know a few properties of ash, can you write any two uses of ash which you had not known before?

In North-Eastern parts of India, ash from banana leaves is a culinary item. People mix the ash with water, allow the solid to settle. They take the supernatant and add it to food dishes during cooking.

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Ideally this unit should give some scientific assessment for some folk uses of ash. For example, its alkaline nature and water adsorbing property is used in disinfectant uses such as for treating human excreta, cleaning up of potentially infectious bio-fluids, for pest management in agriculture etc. This may give people some insights into its chemistry and they may stop considering it as an inert substances and may also think of some novel creative uses of ash, or even encourage further exploration of the properties of ash.

In many other parts of the country, *ksharas* were prepared from ashes and used for traditional medicinal preparations. For example, *muli ka kshar* (radish kshar) was prepared by drying radish, burning it to ash, obtaining water filtrate from this ash, and boiling this ash to dryness. The solid obtained from this process is basic in nature and used in medicines for acidity treatments.

At the end of the unit, teacher can also initiate a discussion on why the colour of the ash is grey. The black colour comes from incompletely burnt carbon (and hence the ash which is incompletely burnt will be darker in colour), whereas complete burning leads to almost complete removal of black carbon. What is left is metal compounds and silica (which is white). Interestingly, the metals which are predominantly present in largest amounts in plants (such as sodium and potassium) have most compounds white in colour. Compound of metals like iron, nickel, which are present is plants in very small amounts, can be coloured and impart slight colour shades like, red, orange or green shades to the ash.

Suggestions for further extension:

1) Once the students have learned about ion analysis in higher classes, they can analyze the ions or salts present in different ashes. They can also analyze ash from different parts of plant, eg. ash from burning leaves, ash from burning wood, and ash from burning roots, which will indicate different concentrations of elements in different part of the plant.

2) Students can boil the water extract and see that they can get much concentrated alkali solutions (with higher pH values) than the extract. But this part must be done under teachers' supervision as concentrated alkalies can be harmful.

Suggested Readings

1. A good discussion on various chemical substances in wood ash and their dissolution in water is available at: Steenari B.M. et al. (1999) Evaluation of the leaching characteristics of wood ash and influence of ash agglomeration. Biomass and Bioenergy, Volume 16 (2), Pages 119-136. Weblink: www.sciencedirect.com/science/article/pii/S0961953498000701
2. A review on composition and chemistry of ash and correlation with original plants material is available in this article:
   J.O. Babayemi, K.T. Dauda, D.O. Nwude and A.A.A. Kayode (2010) Evaluation of the Composition and Chemistry of Ash and Potash from Various Plant Materials-A Review
   Journal of Applied Sciences, Volume: 10 (16) Page 1820-1824. Weblink: http://docsdrive.com/pdfs/ansinet/jas/2010/1820-1824.pdf