

NEW CLUES TO ORGANIC DETOXICATION OF WATER

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A note for the readers

The author was engaged in developing some eco-friendly and low-cost processes of water detoxication, from 2004 to 2005, with a multiple objective. The current report briefs the reader about the objectives and processes involved particularly in the phase-II of the experiment that concluded the 1st round of the initiative. Since the core objective was in public interest and not in the commercial interest of the organization(VASUNDHARA), hence many important findings were first disseminated through a press release / press meet on 15th November'05, and the print- as well as electronic media covered the same.

The conclusions made in this report are based on the assumption that the Regional Research Laboratory (a Govt of India undertaking) has done its work(our assignment) perfectly within the acceptable limits of error. We however have always stressed on the fact that our findings are basically the clues that can be utilized for several kinds of development. Some of the aspects of this experiment may be challenged by the scientific community, but it must be kept in mind that as a non-government organization working on different kind of interventions, we have several limitations and have tried to do whatever best possible within those limitations. We strongly encourage those who are free of such kind of limitations, to utilize these clues in the greater interest of the mankind.

The report of 23rd December'05 did not reveal the identity of three ingredients owing to the proposed patenting of the processes corresponding to the same. However, now that the patent applications have been filed, these processes have been described in this revised report. Further, certain clarifications have been received from RRL in the meantime on the basis of which necessary corrections have been made and fore readers' convenience, have been shown in bold with a reduced font size, in paragraphs requiring attention. We hope this revised report would be more useful than its parent copy.

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NEW CLUES TO ORGANIC DETOXICATION OF WATER

Introduction:

Vasundhara(www.vasundharaorissa.org) is a non-government organization based at Bhubaneswar. Since last 13 years it has been a pioneer in the field of addressing issues relating to forest-people relationship, and has always tried to strengthen community forestry initiatives through various interventions. The trust that it has earned through years of sincere and committed approach has facilitated a collaboration with many national- and international organizations to pursue activities related to the livelihood of people encompassing all aspects of natural resources(like, land and water).

Objective:

In 2003, while implementing some developmental work in Kodalapalli, one of the remote villages of Ranapur block(Nayagarh district, Orissa), the concerned officer of this organization came to know that the villagers had been asked by the government officials not to drink the water of a particular tube well. The villagers said they were not explained the reason behind this advice. Since many parts of the Nayagarh district are known to be fluoride-affected, hence it was decided to get the water of all the available sources tested in a competent laboratory. Accordingly, samples were collected and sent to the State Pollution Control Board for analysis for pH, turbidity, fluoride, SO₄, total hardness, soluble iron, and for pathogens, TC and FC. The analysis report revealed that the focused tube well had high turbidity(74 NTU) and higher content of iron(5.97 mg/litre); but another water source(shallow dugwell) had fluoride beyond permissible limits, i.e. 2.34 mg/litre. Water sources in a neighbouring village were also identified having a similar problem. The next question was how to provide a solution to this, but it was soon learnt that special filters would be needed for that. These special filters are usually not readily available in the market; and not only their cost but also the maintenance at rural level did not appear affordable particularly at the level of the rural poor in those remote parts¹. These chemical filters need careful operation and maintenance for proper purification of water, and unless there is an external support(in this case, from Vasundhara) the local people are not expected to be capable of doing all that themselves. It was under these circumstances that we planned to develop some low-cost, simple and eco-friendly methods for this kind of problem so that the solution can be sustainable even at the level of the illiterate rural poor.

It was at this time that the organization was concerned with the insecurity in the NTFP-dependent livelihood of millions of poor and disadvantaged people of the state owing to limited and unstable market demand of several important non-timber forest products like Sal seeds and Kendu leaves. The case of Mahua(Mahul) has been quite ironical as the primary collectors collect it mostly for consumption by makers of *mahuli*, a liquor stronger than that brewed from rice locally, and which has been detrimental to their

¹ The Rural Technology Department of RRL, Bhubaneswar has developed a low-cost ceramic filter candle, 'Terrafil', that is claimed to be capable of removing physical impurities, but also soluble iron, fluoride, and some other chemical contaminants.

family life. Hence, it was thought to develop some alternative and valuable uses of such natural products so that a dignified and reliable dependency on the same is possible.

One of the simultaneous objectives was to provide a solution to otherwise irreversible diseases like arsenicosis and fluorosis. These diseases are caused basically due to regular intake of water having undesirable concentration of arsenic and fluoride, etc.. Blue baby syndrome is caused due to an undesirable intake of nitrite (NO_2) which is the toxic form of nitrate (NO_3). Both drug development and clinical tests being beyond our capacity, we attempted to see if some herbal remediation is possible in water so that it can be used as a clue to drug development and clinical tests in the human body.

Experimental design(phase-I):

Phase-I of the experiment was carried out in the last quarter of 2004. The criteria for selection of ingredients were as under:

- Clues available in ancient texts/books of nature cure/indigenous knowledge systems
- Common house-hold items
- Resources that are available plentifully, but of hardly any use or of single commercial (non-medicinal) use. The experiment tried to explore new horizons for the utilization of such items.
- Random selection

The parameters(radicals) specified in the following paragraph were selected because these are among the major common sources of water contamination. Arsenic, fluoride, iron and chloride often result from geological anomalies, whereas aluminium is consumed from the food cooked in aluminium cookware. Residual free chlorine comes from excess chlorination of municipal water. The concentration of parameters was decided usually on the basis of their permissible limit as prescribed by the Bureau of Indian Standards. The values were often taken significantly higher than this limit so as to see if the ingredients can be effective at that level. Although natural ground water does not normally contain such a higher concentration, industrially polluted water may have a much higher toxicity and hence this experiment can be also correlated to that.

Initially, it was planned to collect water samples from select wells on the basis of the report of Central Ground Water Board so that highly contaminated(natural) samples could be collected. However, after discussion(informal) with some of the officials of CGWB at Bhubaneswar it was found that this would be difficult because identifying the wells would not be easier, and also this may consume more time and money. Further, owing to the possibility of a considerable fluctuation in the wells identified by CGWB, there was no guarantee that our samples from the same well would be having the same concentration as enumerated in the CGWB report. Hence, it was decided to use custom-made('synthetic') samples/solutions.

Accordingly, the Regional Research Laboratory(RRL), Bhubaneswar was requested to provide, on payment basis, 13 samples(each one litre) each with the following specification:

Aluminium-5 mg/litre(parts per million or ppm)
Arsenic(inorganic/pentavalent)-5 mg/litre
Chloride-10000 mg/litre
Fluoride-15 mg/litre
Iron(ferric)-10 mg/litre
Nitrate-300 mg/litre
Residual free chlorine-2 mg/litre

The basis of taking all the radicals in one solution was not only convenience in the proposed treatment and analysis(like, reducing the number of samples to be handled or treated), but also some financial limitations(more is the number of samples, more the cost of analysis). Moreover, the scientist who was consulted for his opinion on this, assured that there would not be any considerable problem so far our objective was concerned; and hence we decided to go with the mixture although we were ready to go for single-radical samples had we been told that the mixture would not serve our purpose².

These samples were to be treated at our end by natural ingredients. More than 17 natural ingredients were used in the experiment, among which most were non-timber forest products(bark, leaves, fruits/seeds, etc.). Some were used in combination form, and hence the number of samples was reduced. Most of the ingredients were used in the form of their aqueous extracts.

Quality glass beakers were used for soaking some ingredients in water, and a new stainless steel pressure cooker was used for boiling. Sieved solutions were transferred to new(washed with distil water) stainless steel pots. The custom-made samples were received from RRL on 5th November'04, and were treated between 5.30 pm to 6.45 p.m. on 7th November. Each 1 litre bottle was treated by first removing 100 ml solution from it and then adding to it an equal volume of any of the extracts, except in case of the untreated(UT) one, which remained intact. In a sample codenamed as DM, 100 ml water was replaced with equal volume of demineralized(distill) water. The sample bottles were not shaken till 9.45 a.m. on 8th November.

The treated samples, alongwith those marked UT, were delivered to RRL for further analysis on 9th November. However, the identity of the extracts used in the treatment was not disclosed to RRL. They reportedly started the analysis after 17th November and submitted the results on 30th November'04..

Analysis at RRL found that our experiment had not been successful in case of iron, chloride, aluminium and fluoride; i.e., the extracts used were not found effective in such cases so far the removal was concerned. However, bamboo(*Dendrocalamus strictus*) leaf extract emerged as the most effective ingredient in case of arsenic whereas Pan(*Piper betle*) leaf extract successfully removed nitrate without any production of nitrite. Many other ingredients were found to be differently effective in various cases excluding chloride, iron, aluminium and fluoride so far a reduction in the level of concentration of the radicals is concerned. Tamarind pulp extract had almost no impact on fluoride although the intake of tamarind has been claimed to be helpful in checking fluorosis. On the other hand, the extract prepared from amla powder performed unexpectedly by recording the highest concentration of aluminium and fluoride individually probably by breaking the bonding in Aluminium trifluoride that was naturally formed in the mixture. More details on this phase are available at www.vasundharaorissa.org/Organicdetoxicationofwater.pdf .

² As will shall see later in this report, the handicapped opinion of the consulted scientist did damage the relevancy of the experiment though partly, but at the same time the experimental design led to certain new clues which were originally not expected (like, impact on Al₂F₃).

However, the major lacuna in the experiment was the extremely low pH(around 2) of the solutions in which the success cases were detected. Such a high acidic nature of water is not usually encountered under general circumstances. Further, the success was in a solution wherein so many radicals were present in quite considerable quantity which is again an unnatural condition. It was therefore felt to change the strategy for wider applicability. Accordingly, the second phase of the experiments was carried out in June 2005.

Experimental design(phase-II):

In phase-II, RRL was asked to see the effectivity of each of the 20 different organic extracts(supplied by Vasundhara without disclosing the identity of the ingredients used) on water samples(at pH 6.5 to 8.5, if possible) having the following specifications:

<i>Parameters</i>	<i>Desirable(D)/Permissible(P) limits in drinking water as per IS-10500 standard prescriptions(in mg/litre unless otherwise specified)</i>	<i>Concentration in mg/litre(unless otherwise specified)as required for the experiment</i>
Arsenic (pentavalent)	0.05 ³ (D) for total arsenic	5
Aluminium	0.2(P)	5
Fluoride	1.5(P)	5
Chloride	1000(P)	3000
Manganese	0.3(P)	5
Iron(ferric)	1(P) for total iron	20
Residual free chlorine(RFC)	0.20(D)	20
Pesticide	0.001(P) g/litre	1 gram/litre
Mercury	0.001(D)	5
Chromium(hexavalent)	0.05(D)	5
Lead	0.05(D)	5
Zinc	15(P)	30
Copper	1.5(P)	5
Mineral oil	0.03(P)	3
Nitrate	100(P)	350

RRL was further instructed to use each extract, after filtration (so as to take maximum possible precautions to avoid adsorption of any radical) @25 ml per 250 ml of water sample, and to allow the extract 4 hours to interact with the artificially contaminated water samples. Each extract was to be allowed to interact with 15 different radicals individually.

This time the number of radicals was more so as to extend the purview of the experiment. Their concentration was changed in some cases, and the sample numbers were also changed in most cases as compared to that in phase-I. The list of ingredients used for preparing the aqueous extracts was also not the same as some used in phase-I were not

³ The WHO specification is 0.01 mg/l; however experts in India think that owing to the limited infrastructure available with the concerned water supply agencies of the government, 0.02 mg/l may be adequate for Indian conditions.

included this time while many new items were tried for the first time. Method of preparation of extracts was the same, but there was a change in few cases(like, in case of Pan leaves boiled extract was used this time).

RRL was supplied with 20 different extracts on 2nd June'05, and they submitted their final report of analysis on 12th September(vide their letter # PMEED/SKM/2005, dtd.12-09-2005). As per our requirement, they first prepared necessary synthetic solutions and got the same treated with our extracts thereafter. Before treatment, they kept the extracts in a refrigerated condition though the analytical work was done at room temperature. However, they did not work on mineral oil and pesticides due to some technical limitations.

In most of the cases, the addition of extract did not make any major objectionable change in the pH; hence the reaction took place under a more or less acceptable condition of pH. However, in case of mercury, the pH was around 3 and hence the scientists at RRL added some NaOH⁴ of known strength (like, N/10 or N/20) without substantially affecting the volume, just to maintain the pH around 6. Further, with consent from us, they decreased the concentration of Zn to 5 mg/litre as a concentration 30 mg not only seemed to be extremely unnatural but also there was a risk of some unwanted mechanism.

The performance/effectivity of the extracts was shown in terms of the % of removal taking the initial concentration(after addition of extract but before allowing 4-hr. reaction) and the final concentration(after addition of extract allowing 4-hr. reaction) as two measuring points. The initial concentration was actually calculated taking into account the level of concentration (e.g., 5 ppm) with an added volume(of the solution of the radical plus that of the extract; for instance 250 ml of distill water + 25 ml of extract + 1.25 ml of standard fluoride solution, hence the 'initial concentration' being calculated as 4.52 ppm).

The analysis report revealed(as interpreted on the basis of correlating results against sample numbers as provided by RRL, with the actual identity of ingredients corresponding to sample/extract numbers against which RRL was asked to do the analysis) that the extract of *Vanda tessellata*, a common epiphytic orchid(locally known as 'rasna' though some other species are also known under this name) in many parts of Orissa having no commercial demand, was very effective against arsenic. Similarly, the dry ginger extract was quite effective against nitrate without any substantial production of nitrite.

Sample # 5 represented almost the non-reactive phase since the ingredient used, i.e. jabakshyara⁵, seemed to be insoluble in water and hence the 'extract' thus prepared acted more or less as pure distil water after filtration. Hence, this has been otherwise referred to as the 'normal condition'.

⁴ The consent was given on the basis of an assurance from their side that adding NaOH in such a small quantity would not cause any harm so far the reaction of the extract with the radicals, as well as health impacts are concerned. However, independent researcher Deepak Bhattacharya, while commenting on our experiment, suggested that CaOH would have been better. **On behalf of RRL it was explained later that CaOH was not preferred in order to avoid an undesirable increase in the hardness of the solution.**

⁵ There is some doubt if the ingredient available in the market as 'jabakshyara' was a genuine preparation. It may be noted here that more than one 'varieties' are available in the market under the same name but having considerable difference in the price, and what was supplied by one of the most reliable herbs traders of the state, as genuine 'jabakshyara' during the 1st phase of the experiment was replaced by a more costlier powder by the same person during the 2nd phase without any justifiable reason. As per Ayurveda, the jabakshyara powder is very soluble in water whereas in our case we found it otherwise.

The findings can be summarized as under:

<i>Name of the ingredient(extract)</i>	<i>Method of extract preparation</i>	<i>Field of effectivity</i>	<i>Remarks</i>
Bamboo(<i>Dendrocalamus strictus</i>) leaves	50 grams dry leaves boiled in a pressure cooker in 1 litre distil water(dw) for about 10 minutes	RFC, mercury, arsenic	Effectivity more in case of mercury than arsenic
Pan(<i>Piper betle</i>) leaves	100 gram fresh leaves boiled in a pressure cooker in 1 litre 'supply'(PHD) water for about 10 minutes; slight turmeric powder added to the solution just to create a camouflage as the pan leaf extract was otherwise easily recognizable by its odour and taste.	Mercury, RFC, chromium, fluoride, aluminium	It is to be seen if the juice of fresh leaves is more effective against fluoride.
Methi(<i>Trigonella foenum-graecum</i>) seeds	60 grams soaked for about 17 hrs. in 600 ml distil water	RFC, aluminium	No remarkable performance
Karanj(<i>Pongamia pinnata</i>) bark	100 gram dry bark boiled in a pressure cooker in 1 litre distil water(dw) for about 10 minutes.150 ml dw was added to this solution after boiling.	Arsenic, RFC	Removal of arsenic by 52.43% without pptn..
Karanj(<i>Pongamia pinnata</i>) leaves	50 gram dry bark boiled in a pressure cooker in 1 litre distil water(dw) for about 10 minutes.	Lead, RFC	Removal of lead by 55.31% without pptn..

Nirmala(<i>Strychnos potatorum</i>) seeds	90 grams dry seeds soaked for about 17 hrs. in 600 ml distil water(100 ml added dw added later to maintain the quantity of the solution required)	Lead, zinc, RFC, arsenic	Very effective against zinc(44.91% removal without precipitation)
Jabakshyara(the alkaline powder supposedly extracted from the ash of <i>Hordeum vulgare</i>)	20 grams of this powder soaked for about 17 hrs. in 600 ml distil water	Nil	Represents the non-reactive stage
Harida(<i>Terminalia chebula</i>) fruits	90 grams dry fruits soaked for about 17 hrs. in 600 ml distil water(100 ml dw added later)	Aluminium, manganese	
Bahada(<i>Terminalia bellirica</i>) fruits	90 grams dry fruits soaked for about 17 hrs. in 600 ml distil water(100 ml dw added later)	RFC, mercury, aluminium	More effective than Harida in some cases
Rasna(<i>Vanda tessellata</i>) plant	250 gram fresh plant boiled in a pressure cooker in 1 litre distil water for about 10 minutes(100 ml dw added later)	Arsenic, aluminium	Highly effective against arsenic(about 73% removal without precipitation)
Bendo seeds(botanical identity could not be ascertained)	70 grams dry seeds soaked for about 17 hrs. in 600 ml distil water(100 ml dw added later)	Arsenic, mercury, chloride, aluminium, RFC	Removal of arsenic by about 59%(with pptn.) and mercury by approx. 45% (fine pptn.)
Sunthi(dry ginger)	100 grams soaked for about 17 hrs. in 700 ml distil water	Nitrate, mercury, arsenic, aluminium	Very effective(55.24%) against nitrate, production of nitrite being confined to only 2.92 ppm(no precipitation). Also, considerably effective against mercury and arsenic

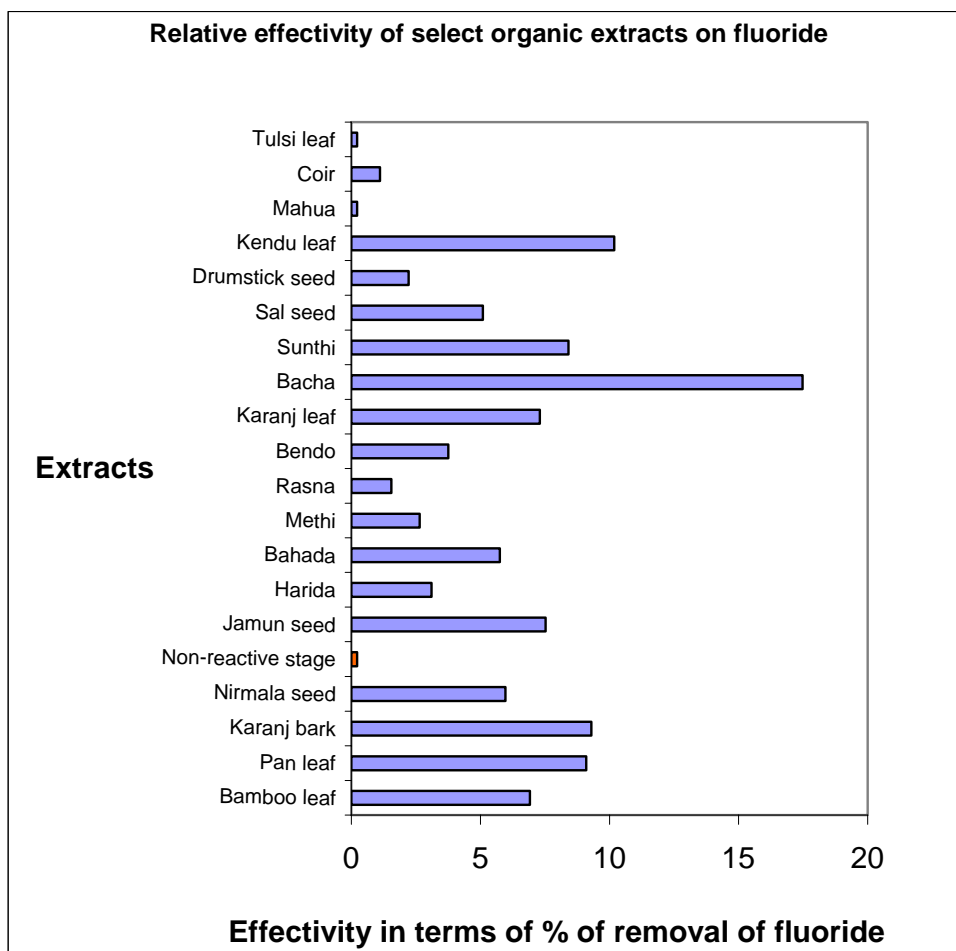
Sal(<i>Shorea robusta</i>) seeds	70 grams dry kernels soaked for about 17 hrs. in 600 ml distil water(100 ml dw added later)	Chloride, mercury, RFC, aluminium	Most effective against chloride(46.59% with slight pptn.)
Kendu(<i>Diospyros melanoxylon</i>) leaves	70 gram dry leaves boiled in a pressure cooker in 1 litre distil water for about 10 minutes(100 ml dw added later)	Lead, arsenic, nitrate, fluoride	Seems to obstruct the removal of manganese under normal conditions. Effectivity of the juice of fresh leaves is to be studied.
Mahua(<i>Madhuca indica</i>) flower	70 grams dry flower soaked for about 17 hrs. in 600 ml distil water(150 ml dw added later)	Mercury, copper, aluminium, nitrate	Removal of mercury and copper by about 50% and 41% respectively. Production of nitrite more in comparison to that in case of sunthi.
Drumstick(<i>Moringa oleifera</i>) seeds	70 gram dry seeds boiled in a pressure cooker in 1 litre distil water for about 10 minutes	Nitrate, arsenic	No significant effectivity in any case although drumstick seed powder or kernel has been elsewhere found to be effective against fluoride, etc.(by adsorption?).
Tulsi(<i>Ocimum sanctum</i>) leaf powder	35 grams powder soaked for about 17 hrs. in 600 ml distil water(100 ml dw added later)	Lead, aluminium, nitrate, zinc, RFC	About 46% removal of lead with pptn..
Bacha(<i>Acorus calamus</i>) rhizomes	100 grams soaked in 700 ml dw for about 17 hrs.	Copper, lead, arsenic, nitrate, RFC, fluoride	Removal of copper by 99.55%(pptn.), lead by 73.89%(pptn.), arsenic by 53.32%(pptn.), and fluoride by 17.48%(no visible pptn.)

Coconut coir	55 grams boiled in 900 ml dw for about 10 minutes(250 ml dw added later)	Chromium, zinc, RFC	Removal of hexavalent chromium by 32.73% with slight pptn.
Jamun seeds(<i>Syzygium cumini</i>)	90 grams soaked in 600 ml dw for about 17 hrs.	Mercury, RFC	Removal of mercury by 73.09% with no visible pptn.

The above table only reflects some comparatively significant findings in each case, and does not necessarily mean that a particular ingredient is absolutely ineffective on all radicals other than those mentioned against it though in a few cases it has been actually so. For instance, tulsi leaf extract had less than 1% effectivity in case of chloride and fluoride, but its performance was comparatively better in case of chromium(19.83%) and arsenic(16.15%) though this much effectivity was still lower in comparison to that in case of lead or nitrate.

It was found that bamboo leaves were less effective this time against arsenic, and pan leaves had almost no effectivity against nitrate, as compared to the phase-I experiment. Difference in pH and other conditions may explain this.

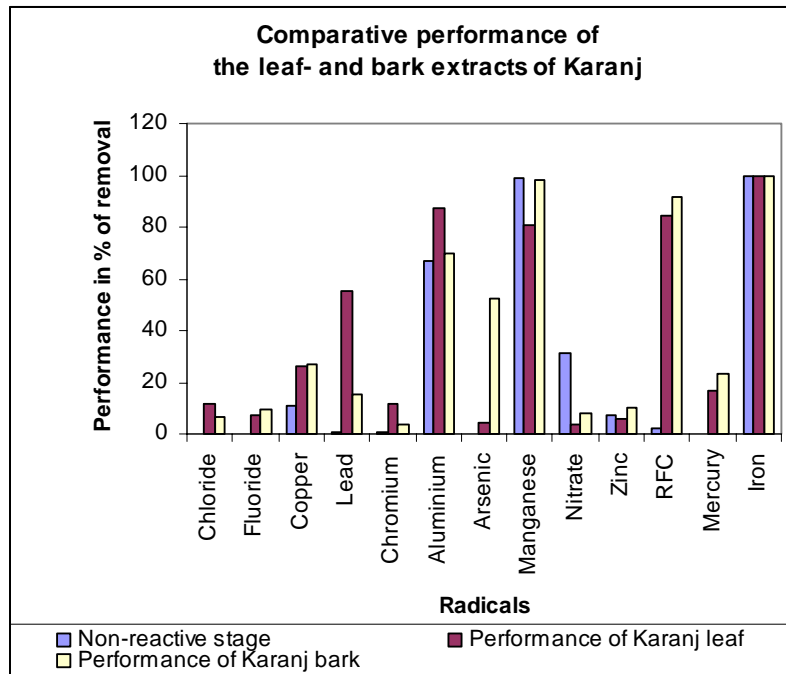
In case of fluoride, the maximum % of removal was 17.48 effected by the extract of *Acorus calamus*, and three different extracts had an effectivity above 9 %. Considering the nature of fluoride ions, even this much has been considered to be significant.



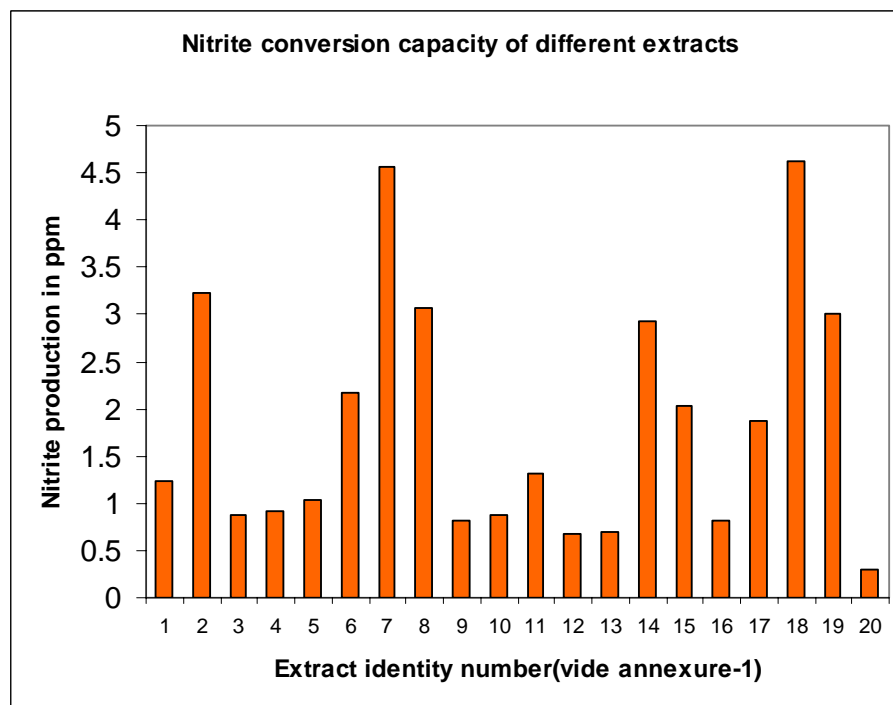
In case of iron, it was found that there was a natural reduction in the concentration by about 99% even under ‘normal conditions’ (i.e., without any intervention from an extract). Similar situation was observed in case of manganese and aluminium with their % of removal by 98.89 and 66.69 respectively. However, some extracts either increased the average % of removal or decreased it substantially. Further, as in case of iron, although the % of removal was almost the same with or without the addition of extract, the nature of reaction differed; i.e., some extracts(e.g., pan leaves) caused precipitation while others(e.g., rasna) maintained the solution ‘clear’.

In case of RFC, the minimum % of removal in case of all the extracts(jabakshyara excluded) was 71.39 as against 1.90 under the ‘normal condition’.

A very interesting comparison emerged in case of the performance of the leaf- and bark extracts of the same species, i.e. Karanj. While the bark performed well in case of arsenic in both phases of the experiment, the leaf extract had almost no impact on arsenic. Instead, the leaf extract performed well in case of lead unlike the bark extract.



Mahua and Harida extracts appeared to be producing the highest amount of nitrite(NO_2) followed by Pan leaf, Bahada, Sunthi and coconut coir. Harida produced 4.57 ppm of nitrite against only 7.87% removal of nitrate while Mahua produced 4.62 ppm of nitrite against 48.66% removal of nitrate. Tulsi leaf and Bacha recorded the lowest level of NO_2 conversion against a considerable(32 to 34%) removal capacity for NO_3 .



Advantages and applications:

The above-mentioned processes of water detoxication are simple, eco-friendly and low-cost; and hence can be applied directly (in some cases) or after suitable improvement, at the domestic level to make the rural poor self-reliant in water detoxication. The successful ingredients can also be used to develop herbal drugs for the treatment of diseases corresponding to the toxicity of the respective radicals.

At industrial level, these clues can be used either for extraction of metals/chemicals from the water (in those cases where precipitation of the radical is considerable), or to treat the industrial effluents at the source in an eco-friendly manner at a cost much lower than that in the chemical treatment. For instance, in gold mines the beneficiation process generates mercury-rich effluents, and it is to be seen if Mahua and other effective natural ingredients can help solve the problem. Similarly, experts for sewage treatment should study if the application of ginger extract can avoid formation of nitrate.

Our experiment has been able to discover important alternative utilities for Sal seeds, Mahua, Kendu leaves, Bahada and Pan leaves, etc.. Even the lesser-known Bendo seeds, which are locally used in the Gurundia block of Sundargarh district in Orissa to extract an edible oil without having any importance in the market, have been found to be effective in water detoxication. This can be used to develop alternative markets for these products, thus helping lakhs of people dependent on their collection or cultivation.

Vasundhara has applied for patent for three key discoveries: the detoxication capacity of Bacha to remove arsenic, fluoride, lead, and copper; that of Jamun seed to reduce/remove mercury; and that of coconut coir to reduce/remove hexavalent chromium.

Limitations:

One of the major limitations of our experiment is that the effectivity mentioned here is a relative term since a change in the concentration of the extract or the radical can alter this factor. Further, in almost all cases distilled water has been used, and use of NaOH to adjust the pH may not always seem to be a very preferable one (for instance, independent researcher Deepak Bhattacharya says CaOH sourced naturally from lime-bearing rocks would have been much more advantageous).

Wherever cases of precipitation have been detected, the precipitate has not been identified (i.e., it is not known whether it is the extract itself or the contaminant) owing to the limitations of the experiment. Moreover, effectivity on individual radicals does not necessarily imply the same on compounds.

Further, we have used pentavalent arsenic, and not the trivalent one which is said to be about 60 times more toxic than the former. It may be mentioned here that the pentavalent- and trivalent forms of arsenic may convert to each other under certain conditions. For instance, under reducing conditions trivalent arsenic is formed while under oxidizing conditions the pentavalent one is formed. Exposure to air (i.e., aeration) helps convert the trivalent arsenic in water to the pentavalent one (it may take few hours to one day to complete the process, depending on the concentration and exposure), and at this stage if suitable treatment is followed, then the pentavalent arsenic may settle down through precipitation, thus making the upper portion of the water in a tank potable. The presence

of arsenic in drinking water is primarily in the pentavalent form unless it is under a reducing condition, which we have used⁶.

The change in colour, taste, odour and some other physico-chemical properties due to the addition of extracts may be undesirable in some cases. Also, in those cases where the removal of toxicity is possible without adsorption or precipitation, the health impacts of the final(detoxicated) solution are yet to be studied. It may be mentioned here that RRL had initially been asked to identify the chemical reaction which makes the detoxication possible in successful cases, but owing to several limitations at their end plus the huge cost to be incurred for availing this service finally forced us to abandon this part for the time being.

Conclusion:

VASUNDHARA invested a lot in the afore-said experiments not for any commercial purpose, but to help the humanity. Despite a will, shortage of funds and technical limitations at several levels(even in case of government laboratories) have not allowed us to go beyond a certain limit. Still we are satisfied that within our limitations we have discovered(and unknowingly rediscovered in very few cases like Nirmala seeds⁷) some clues that can be used for further user-friendly developments in the field of pharmaceuticals, water detoxication, pollution control, etc.. CSIR has been intimated of these discoveries, and the Secretary, DSIR who is also the chairperson of National Innovations Foundation has been requested to consider a collaborative effort with VASUNDHARA for further developments on these clues. However, response from the Govt. of India is yet to come.

⁶ **Arsenate(trivalent arsenic) is in principle the major culprit because arsenic is released to ground water in this form which is much more mobile than arsenite(pentavalent arsenic). In parts of West Bengal and Bangladesh the presence of trivalent arsenic in total arsenic is 50-60%, and it is not removed directly by filters designed for arsenic(source: Dr.S.K.Acharyya, Emeritus Scientist, CSIR, Dept Geological Sciences, Jadavpur University).**

⁷ A herbal product BIOFLOCCULANT prepared from the Nirmala seeds has been found to have flocculating action in removing radio-active wastes like spent uranium fuel, and also metal contaminants like mercury, cadmium, and lead. It has applications in metal refining also.(Journal of Scientific and Industrial Research, 1994, **53**, 63 quoted in *The Wealth of India*, 2004, First Supplement Series, Vol. 5, p.166).

Annexure-1

Data tables on the performance of disclosed ingredients

Extract	Identity No.	Chloride(removal %)	Fluoride(removal %)
Bamboo leaf	1	3.84(Clear)	6.91(Clear)
Pan leaf	2	7.83(Clear)	9.1(Clear)
Karanj bark	3	6.52(Clear)	9.29(Clear)
Nirmala seed	4	9.19(Clear)	5.97(Clear)
Jabakshyara	5	0.11(Clear)	0.22(Clear)
Jamun seed	6	5.16(Clear)	7.52(pptn.)
Harida	7	13.18(Clear)	3.1(pptn.)
Bahada	8	22.52(pptn.)	5.75(pptn.)
Methi	9	14.54(pptn.)	2.65(Clear)
Rasna	10	1.17(S.pptn.)	1.55(Clear)
Bendo	11	30.55(S.pptn.)	3.76(pptn.)
Karanj leaf	12	11.86(Clear)	7.3(pptn.)
Bacha	13	14.54(Clear)	17.48(Clear)
Sunthi	14	15.86(Clear)	8.41(Clear)
Sal seed	15	46.59(S.pptn.)	5.1(Clear)
Drumstick seed	16	9.19(S.pptn.)	2.21(Clear)
Kendu leaf	17	15.86(Clear)	10.18(Clear)
Mahua	18	0.64(Clear)	0.22(Clear)
Coconut Coir	19	17.21(S.pptn.)	1.11(pptn.)
Tulsi leaf	20	0.38(S.pptn.)	0.22(Clear)

Note: presence or absence of precipitation has been indicated within bracket. S.pptn. means slight precipitation, and 'clear' means no visible precipitation. The identity number corresponds to the sample/extract number against which RRL has tabulated the results.

Extract	Copper(removal %)	Lead(removal %)	Chromium(removal %)	Aluminium(removal %)	Arsenic(removal %)
Bamboo leaf	5.33(Clear)	0.66(Clear)	1.77(S.pptn.)	75(Clear)	22.12(Clear)
Pan leaf	21.68(pptn.)	0(Clear)	25.28(S.pptn.)	95.35(Clear)	13.27(Clear)
Karanj bark	26.99(S.pptn.)	15.49(Clear)	3.34(S.pptn.)	69.69(Clear)	52.43(Clear)
Nirmala seed	22.34(Clear)	60.4(Clear)	15.53(Clear)	71.46(Clear)	44.03(Clear)
Jabakshyara	11.06(Clear)	0.66(Clear)	0.72(Clear)	66.59(Clear)	0.22(Clear)
Jamun seed	10.4(pptn.)	9.29(pptn.)	5.79(S.pptn.)	67.48(pptn.)	7.1(pptn.)
Harida	14.82(pptn.)	1.11(pptn.)	1.43(S.pptn.)	94.91(pptn.)	9.96(pptn.)
Bahada	9.29(pptn.)	4.87(pptn.)	0.72(Clear)	95.35(pptn.)	28.1(pptn.)
Methi	11.5(Clear)	12.83(Clear)	8.12(Clear)	97.57(Clear)	13.94(Clear)
Rasna	10.62(pptn.)	24.11(Clear)	10.75(Clear)	98.45(Clear)	72.79(Clear)
Bendo	31.41(Clear)	22.34(pptn.)	2.88(S.pptn.)	98.01(Clear)	59.1(pptn.)
Karanj leaf	25.88(Clear)	55.31(Clear)	11.95(Clear)	86.95(Clear)	4.2(Clear)
Bacha	99.55(pptn.)	73.89(pptn.)	12.18(S.pptn.)	94.69(pptn.)	53.32(pptn.)
Sunthi	22.79(Clear)	14.38(pptn.)	0.72(Clear)	99.56(pptn.)	39.6(Clear)
Sal seed	17.7(Clear)	0.22(Clear)	1.43(S.pptn.)	99.78(Clear)	10.4(pptn.)
Drumstick seed	12.83(pptn.)	23.67(pptn.)	6.93(Clear)	87.61(Clear)	28.54(Clear)
Kendu leaf	0.66(pptn.)	35.84(Clear)	18.4(Clear)	80.3(Clear)	30.31(Clear)
Mahua	41.59(Clear)	18.14(Clear)	17.2(pptn.)	99.34(Clear)	9.96(Clear)
Coconut coir	9.29(Clear)	23.01(pptn.)	32.73(S.pptn.)	75.66(pptn.)	6.42(pptn.)
Tulsi leaf	3.09(S.pptn.)	46.02(pptn.)	19.83(S.pptn.)	98.01(pptn.)	16.15(pptn.)

Note: presence or absence of precipitation has been indicated within bracket. S.pptn. means slight precipitation, and 'clear' means no visible precipitation.

Extract	Manganese(removal %)	Nitrate(removal %)	Nitrite production(in ppm.)	Zinc(removal %)	RFC(removal %)
Bamboo leaf	98.01(pptn.)	5.37(Clear)	1.23	11.06(Clear)	93.11(Clear)
Pan leaf	77.65(pptn.)	3.77(Clear)	3.23	7.52(Clear)	92.66(pptn.)
Karanj bark	98.01(Clear)	8.33(Clear)	0.87	9.95(Clear)	91.77(fine pptn.)
Nirmala seed	98.45(Clear)	14.46(Clear)	0.92	44.91(Clear)	85.33(fine pptn.)
Jabakshyara	98.89(Clear)	31.16(Clear)	1.03	7.1(Clear)	1.9(Clear)
Jamun seed	98.23(pptn.)	3.05(Clear)	2.17	6.19(Clear)	77.66(pptn.)
Harida	93.58(pptn.)	7.87(S.pptn.)	4.57	7.1(Clear)	76.31(fine pptn.)
Bahada	79.87(pptn.)	2.78(Clear)	3.06	3.76(Clear)	94.23(Clear)
Methi	81.86(pptn.)	5.97(Clear)	0.82	5.53(pptn.)	95.13(pptn.)
Rasna	96.9(Clear)	11.56(Clear)	0.87	5.1(Clear)	71.39(fine pptn.)
Bendo	94.03(pptn.)	3.1(Clear)	1.31	5.53(Clear)	82.59(pptn.)
Karanj leaf	80.87(Clear)	3.4(Clear)	0.67	5.53(Clear)	84.38(fine pptn.)
Bacha	97.66(pptn.)	34.42(Clear)	0.69	7.52(pptn.)	93.11(Clear)
Sunthi	46.23(Clear)	55.24(Clear)	2.92	9.1(Clear)	96.02(Clear)
Sal seed	60.4(pptn.)	4.68(Clear)	2.03	7.1(Clear)	98.71(fine pptn.)
Drumstick seed	63.27(pptn.)	24.23(pptn.)	0.82	8.63(Clear)	88.02(pptn.)
Kendu leaf	47.12(Clear)	34.35(Clear)	1.88	9.29(Clear)	82.92(pptn.)
Mahua	83.41(pptn.)	48.66(Clear)	4.62	4.2(Clear)	74.3(fine pptn.)
Coconut coir	79.2(pptn.)	5.65(Clear)	3.01	26.33(Clear)	76.31(Clear)
Tulsi leaf	60.84(pptn.)	32.5(Clear)	0.29	26.77(Clear)	94.08(Clear)

Note: presence or absence of precipitation has been indicated within bracket. S.pptn. means slight precipitation, and ‘clear’ means no visible precipitation.

Extract	Mercury(removal %)	Iron(removal %)
Bamboo leaf	46.19(Clear)	99.83(S.pptn.)
Pan leaf	51.79(Fine pptn.)	93.11(pptn.)
Karanj bark	23.32(pptn.)	99.89(pptn.)
Nirmala seed	13.68(pptn.)	99.78(Clear)
Jabakshyara	0.22(Clear)	99.78(Clear)
Jamun seed	73.09(Clear)	99.61(pptn.)
Harida	33.41(Fine pptn.)	98.71(pptn.)
Bahada	58.52(Clear)	96.02(pptn.)
Methi	10.99(Fine pptn.)	97.1(pptn.)
Rasna	24.44(Fine pptn.)	99.78(Clear)
Bendo	45.74(Fine pptn.)	99.61(Clear)
Karanj leaf	16.59(pptn.)	99.66(Clear)
Bacha	21.52(Clear)	99.94(pptn.)
Sunthi	50.22(Fine pptn.)	86.95(pptn.)
Sal seed	46.86(Fine pptn.)	88.07(pptn.)
Drumstick seed	18.83(pptn.)	92.37(pptn.)
Kendu leaf	18.16(Fine pptn.)	81.35(pptn.)
Mahua	50(Fine pptn.)	97.48(pptn.)
Coconut coir	23.77(Clear)	99.22(pptn.)
Tulsi leaf	13.68(Clear)	92.22(pptn.)

Note: presence or absence of precipitation has been indicated within bracket. S.pptn. means slight precipitation, and 'clear' means no visible precipitation.

Annexure-2
pH and conductivity data

Extract	Identity No.	Chloride pH(conductivity in $\mu\text{s/cm}$)	Fluoride pH(conductivity in $\mu\text{s/cm}$)	Copper pH(conductivity in $\mu\text{s/cm}$)	Lead pH(conductivity in $\mu\text{s/cm}$)	Chromium pH(conductivity in $\mu\text{s/cm}$)
Blank		6.20(9.16)	6.48(34.8)	6.24(22.4)	5.40(78.1)	5.33(15.2)
Bamboo leaf	1	6.62(8.08)	6.57(104.6)	6.54(75.1)	6.10(77.5)	5.33(15.2)
Pan leaf	2	5.95(8.07)	6.16(157.4)	5.94(314.2)	4.53(131.3)	4.71(137.3)
Karanj bark	3	6.83(8.12)	6.80(193.3)	5.40(260.1)	6.34(172.3)	6.56(176.3)
Nirmala seed	4	5.53(8.25)	5.14(287.1)	6.55(165)	5.86(245.9)	4.67(261.4)
Jabakshyara	5	6.25(9.17)	6.53(49.2)	6.44(34.3)	5.91(88.20)	5.38(33.3)
Jamun seed	6	5.23(8.44)	5.42(347)	5.77(316)	5.08(171.2)	5.63(318.2)
Harida	7	4.55(8.12)	5.27(172.9)	5.12(178.7)	3.75(162.6)	5.08(147.9)
Bahada	8	6.57(8.25)	4.76(324.4)	5.49(299.6)	4.38(298.5)	5.41(303.2)
Methi	9	6.46(8.08)	6.14(112.9)	6.26(90.1)	6.11(86.4)	6.33(99.9)
Rasna	10	6.32(8.97)	6.10(66.20)	5.83(44.6)	6.07(38.4)	6.17(67.1)
Bendo	11	6(8.13)	6.54(196.6)	5.78(183.7)	6.28(188.1)	5.54(178.7)
Karanj leaf	12	6.36(8.11)	6.66(131.1)	6.62(122)	6.61(110.2)	6.40(126.7)
Bacha	13	6.41(8.77)	6.18(922)	6(880)	6.37(918)	5.91(915.3)
Sunthi	14	4.22(8.48)	4.31(576)	4.17(563.6)	4.41(552)	5.11(570.1)
Sal seed	15	4.35(8.02)	5(179)	4.54(155.2)	5.16(151.7)	5.29(154.6)
Drumstick seed	16	6.03(8.11)	6.04(89.7)	5.94(64.2)	6.50(64.5)	6.22(78.6)
Kendu leaf	17	5.58(7.99)	5.81(56.6)	4.82(54.7)	5.91(28.6)	5.82(47.5)
Mahua	18	5.01(8.11)	3.93(307)	3.78(308)	3.35(351)	4.98(309.5)
Coconut coir	19	5.57(8.04)	4.94(121.7)	5.75(100.4)	6.03(91.5)	6.15(98.5)
Tulsi leaf	20	6.73(8.13)	6.28(282.6)	6.33(251.2)	6.64(271.5)	6.47(259.6)

Note- 'Blank' means the solution with treatment by not any extract but by an equal volume of distill water. Treated solutions have been mentioned in terms of the corresponding extracts used for the treatment.

Annexure-2
pH and conductivity data(contd.)

Extract	Aluminium pH(conductivity in $\mu\text{s/cm}$)	Arsenic pH(conductivity in $\mu\text{s/cm}$)	Manganese pH(conductivity in $\mu\text{s/cm}$)
Blank	5.31(967)	5.67(24.5)	6.50(414.2)
Bamboo leaf	7.53(864)	6.20(73.3)	6.12(678)
Pan leaf	6.18(895)	4.48(133.1)	5.18(663)
Karanj bark	5.56(871)	6.73(165.4)	6.64(689)
Nirmala seed	7.68(1049)	6.20(240.3)	6.91(662.3)
Jabakshyara	5.29(959)	5.80(21.3)	6.75(417.2)
Jamun seed	5.43(729)	5.77(304)	6.48(485.1)
Harida	6.04(983)	5.03(164.7)	6.49(385.5)
Bahada	6.15(859)	5.47(298.2)	6.71(609.6)
Methi	6.07(877)	6.24(83.6)	6.61(612.4)
Rasna	6.73(888)	6.28(36.7)	6.90(504.7)
Bendo	6.42(555)	5.97(185.3)	6.48(951.5)
Karanj leaf	6.94(832)	6.44(106.5)	6.20(369.2)
Bacha	6.47(1191)	6.18(903)	6.40(809.4)
Sunthi	6.31(1007)	4.01(565)	6.35(695.1)
Sal seed	6.15(813)	4.43(150.7)	5.29(481.7)
Drumstick seed	6.50(915)	5.99(61.6)	5.80(329.5)
Kendu leaf	6.98(935)	5.27(26.1)	6.85(261.1)
Mahua	6.26(801)	4.36(94.8)	6.92(661.2)
Coconut coir	7.15(992)	4.85(347.1)	7.49(417.5)
Tulsi leaf	6.62(551)	6.48(263.4)	6.8(811.6)

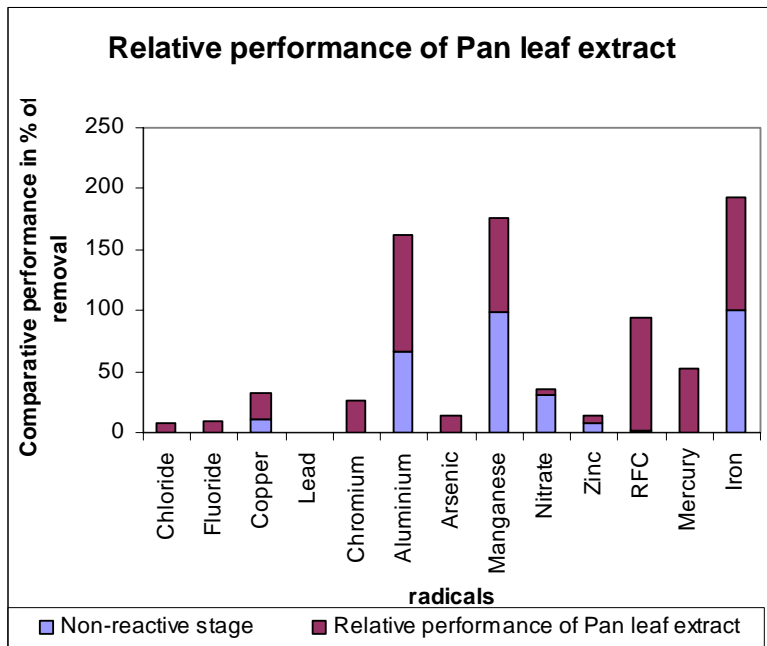
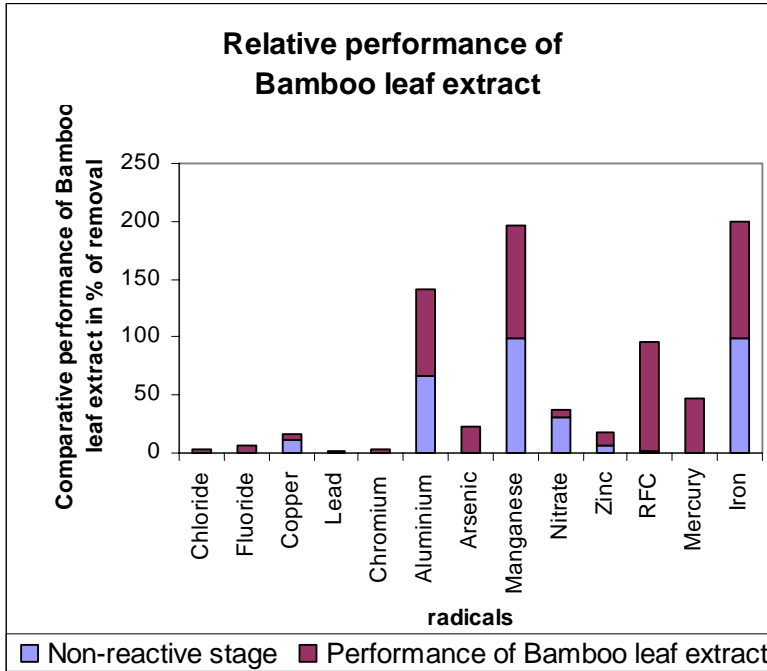
Note- 'Blank' means the solution with treatment by not any extract but by an equal volume of distill water.. Treated solutions have been mentioned in terms of the corresponding extracts used for the treatment.

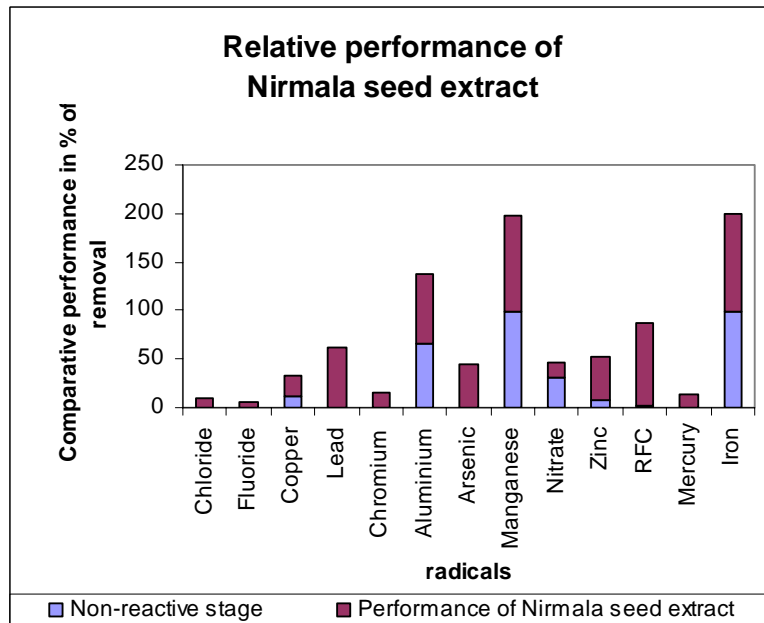
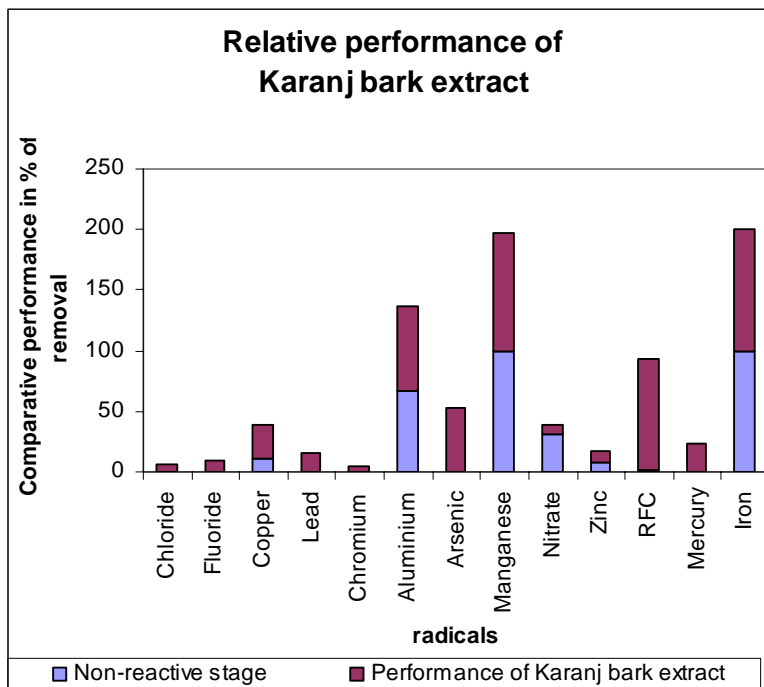
Annexure-2
pH and conductivity data(contd.)

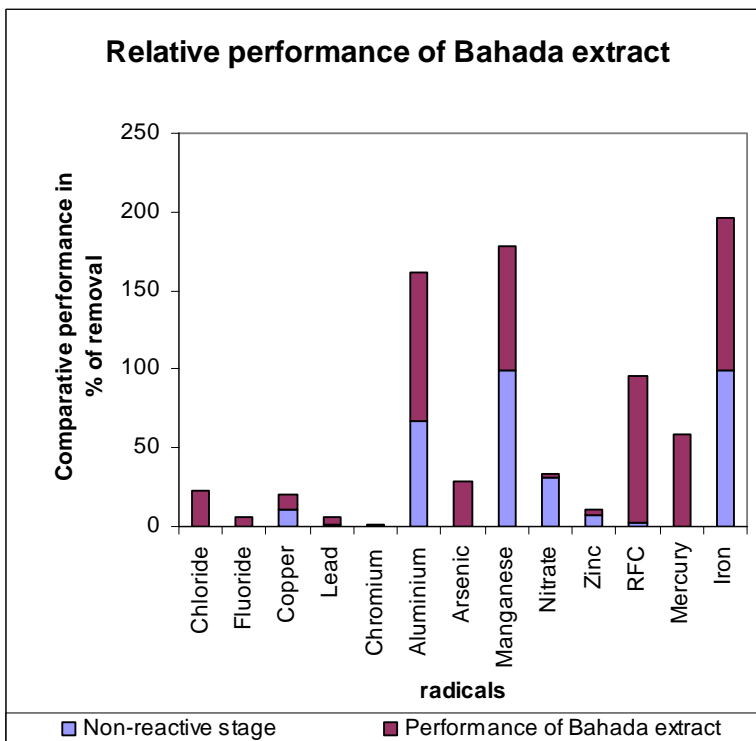
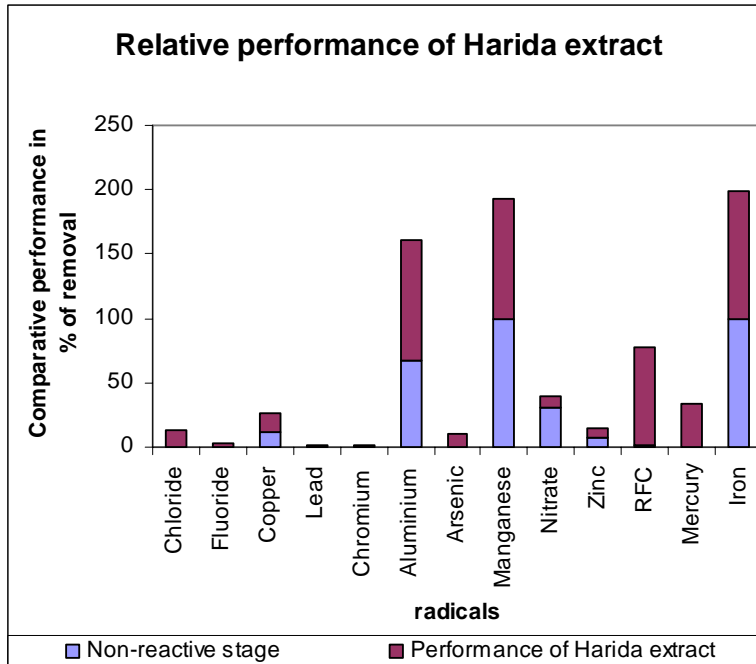
Extract	Nitrate pH(conductivity in $\mu\text{s/cm}$)	Zinc pH(conductivity in $\mu\text{s/cm}$)	RFC pH(conductivity in $\mu\text{s/cm}$)	Mercury pH(conductivity in $\mu\text{s/cm}$)
Blank	5.95(656)	5.82(515)	5.82(123.6)	2.66(979)
Bamboo leaf	6.35(743)	6.13(463)	5.25(132.2)	2.71(808)
Pan leaf	4.52(783)	6.03(501)	5.21(149.4)	2.76(795)
Karanj bark	6.63(824)	6.15(482)	5.32(167.5)	2.76(807)
Nirmala seed	6.60(888)	6.01(621)	5.49(102.5)	2.74(943)
Jabakshyara	6.04(686)	5.90(527)	5.79(117.8)	2.66(871)
Jamun seed	5.46(950)	6.80(408)	5.21(205.3)	3.07(669)
Harida	3.77(813)	5.91(575)	6.11(109.6)	2.71(885)
Bahada	4.38(940)	6.63(499)	5.39(147.2)	2.91(779)
Methi	6.29(742)	6.10(453)	5.44(161.3)	2.73(805)
Rasna	6.16(708)	5.97(476)	6.25(164.7)	2.68(844)
Bendo	5.80(841)	5.30(272)	6.12(170.3)	3.13(510)
Karanj leaf	6.38(783)	6.78(423)	5.82(191.3)	2.77(760)
Bacha	6.29(1539)	6.60(971)	5.79(141.3)	3.27(1172)
Sunthi	4.20(1170)	6.36(723)	6.42(207.8)	3.04(927)
Sal seed	5.36(799)	6.80(388)	5.65(219.3)	2.88(679)
Drumstick seed	6.03(731)	6.24(503)	6.29(157.2)	2.75(852)
Kendu leaf	5.76(700)	6.50(527)	6.03(165.4)	2.70(872)
Mahua	3.35(1001)	6.69(540)	5.42(129.3)	3.07(811)
Coconut coir	4.75(747)	5.97(577)	5.87(164.5)	2.70(928)
Tulsi leaf	6.36(919)	5.56(330)	5.03(169.1)	3.28(532)

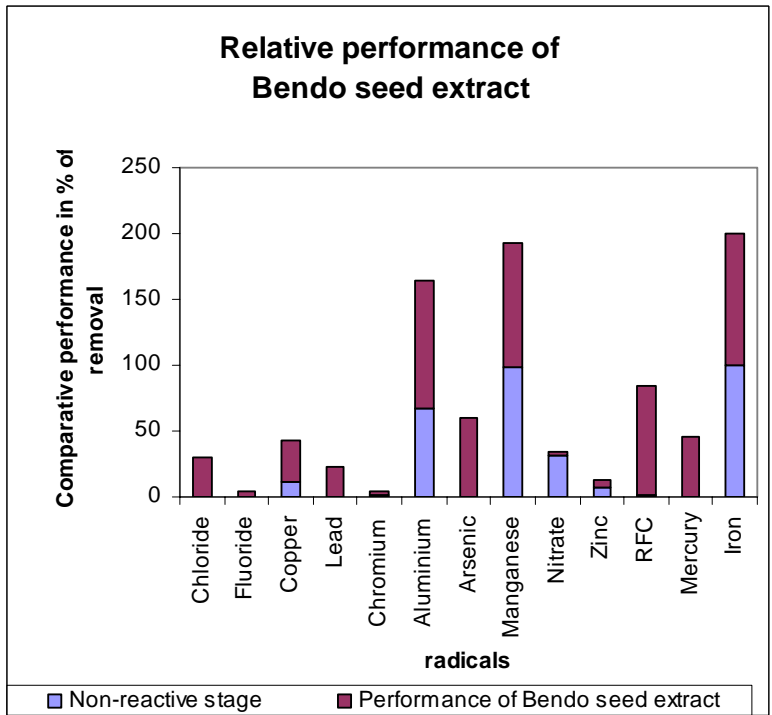
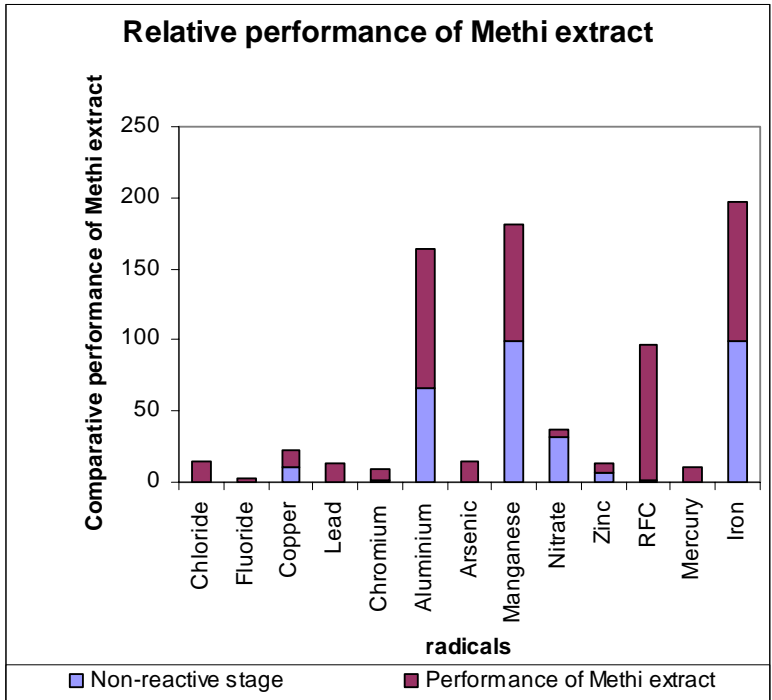
Note- 'Blank' means the solution with treatment by not any extract but by an equal volume of distill water.. Treated solutions have been mentioned in terms of the corresponding extracts used for the treatment.

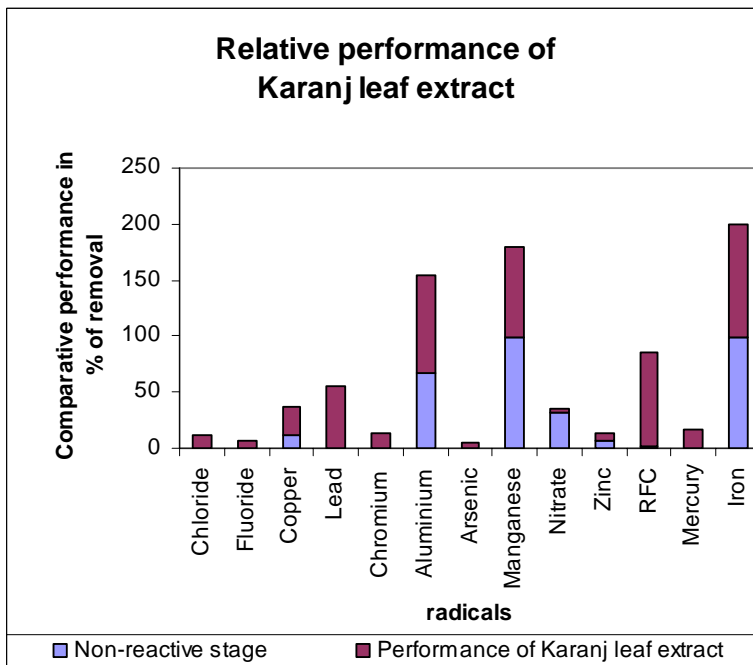
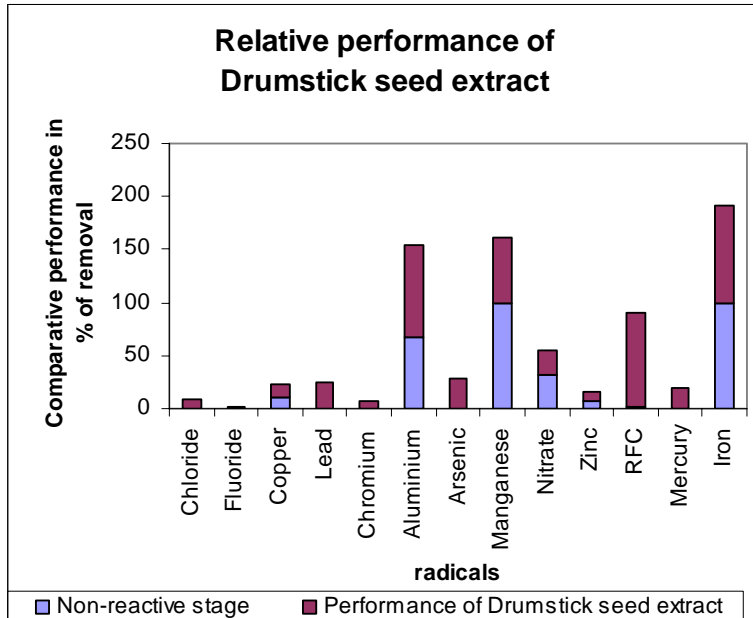
Annexure-3
Performance charts of different extracts

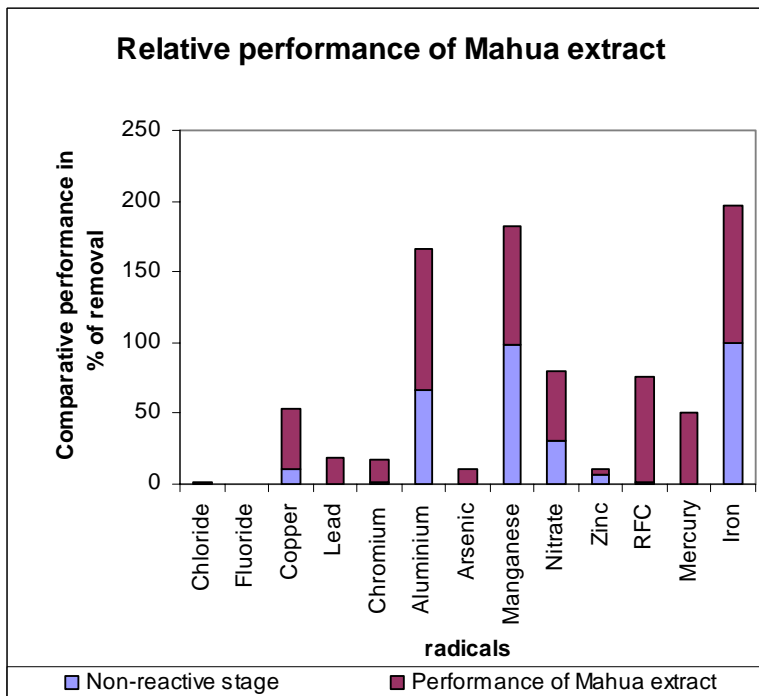
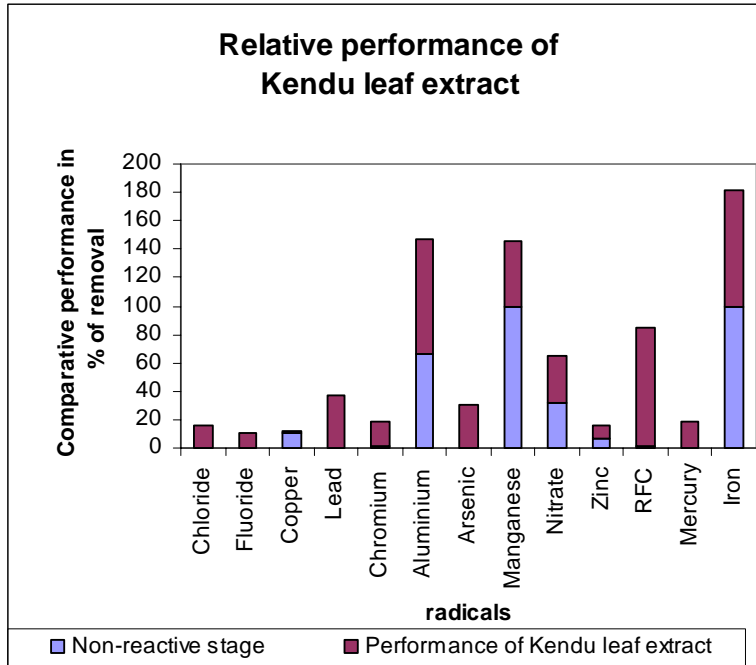


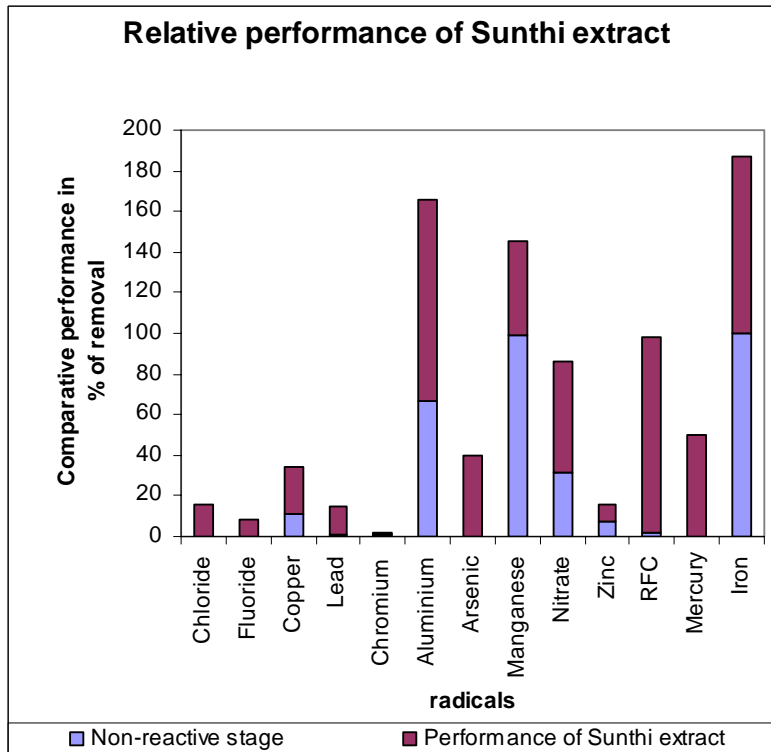
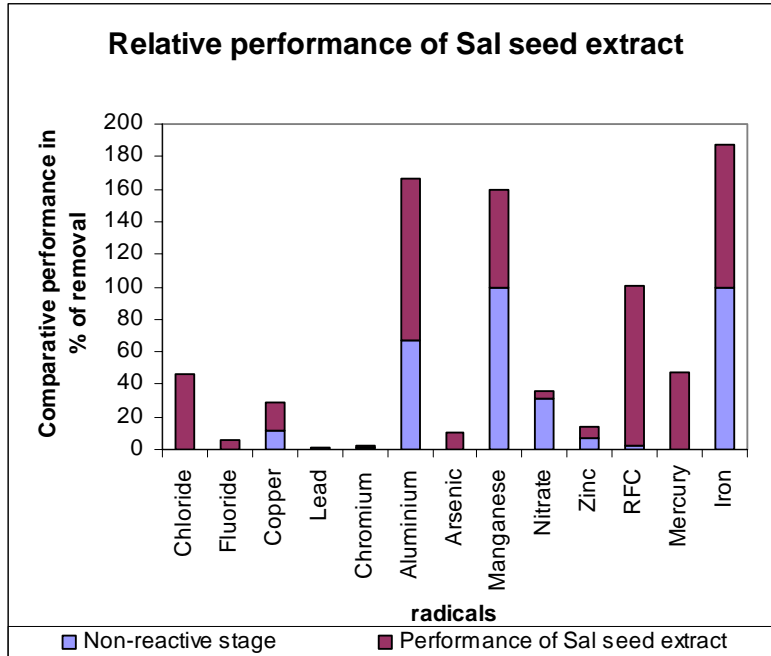


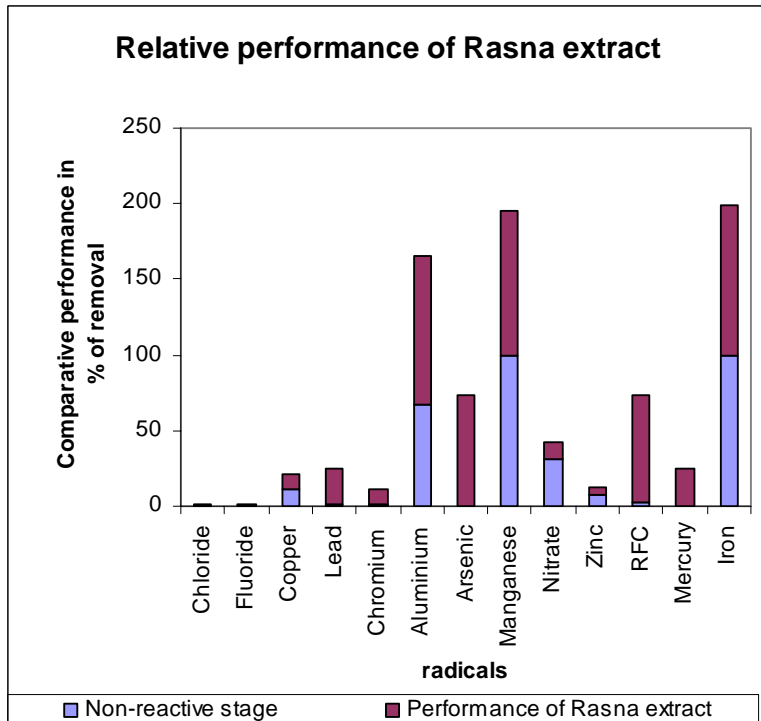
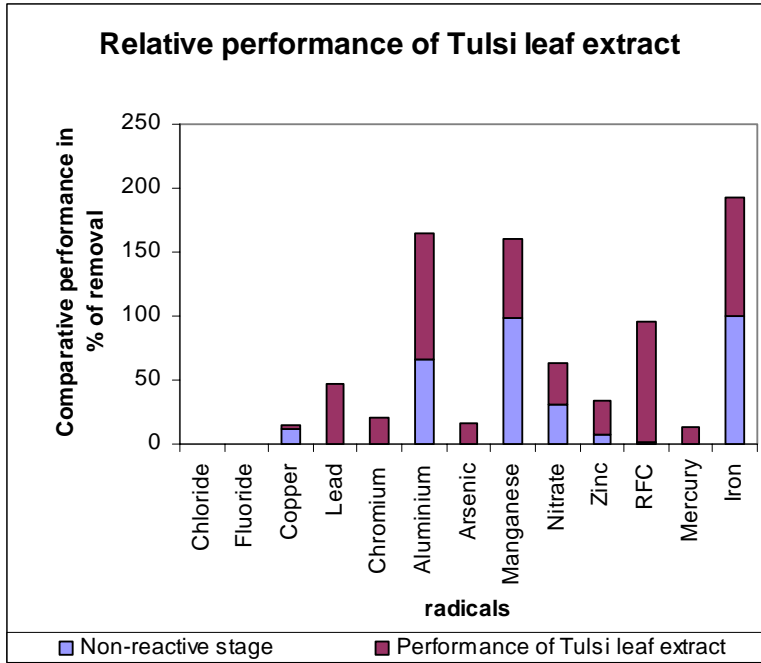






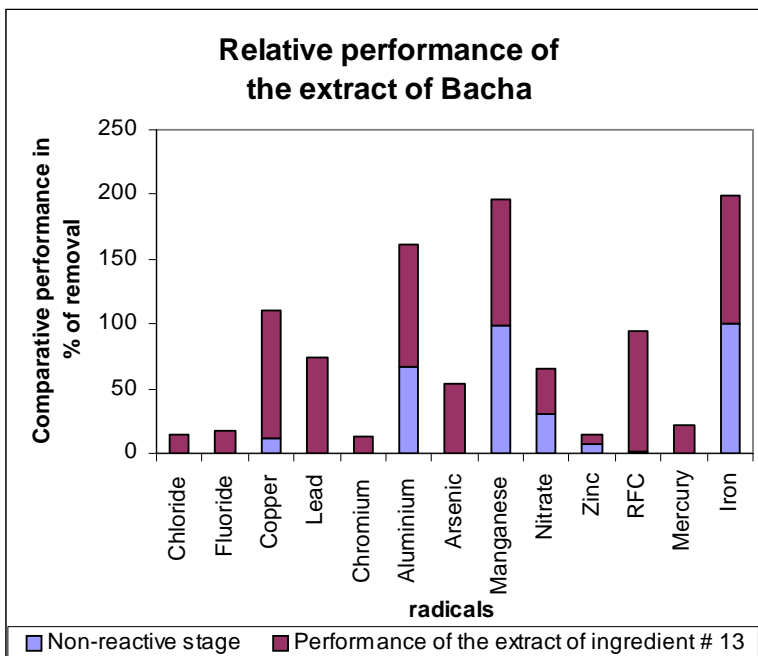
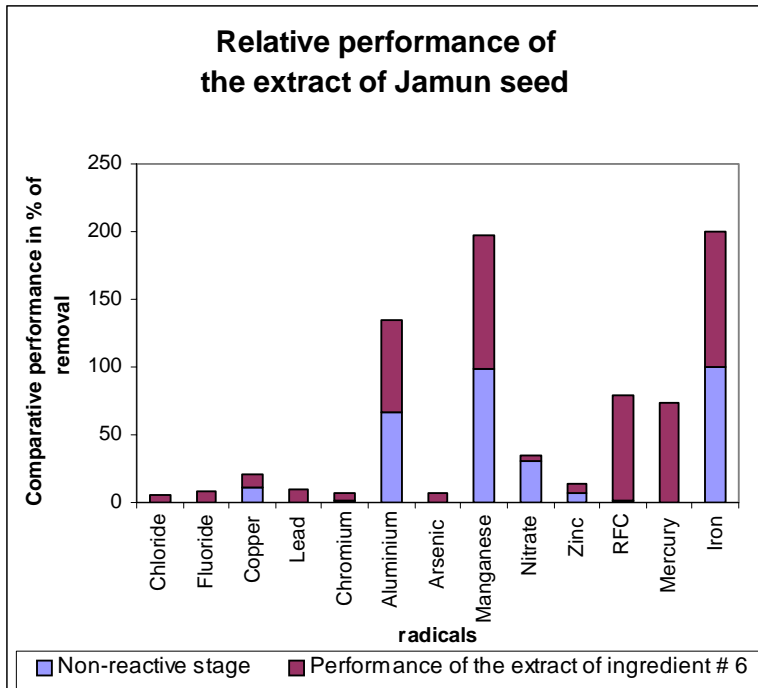




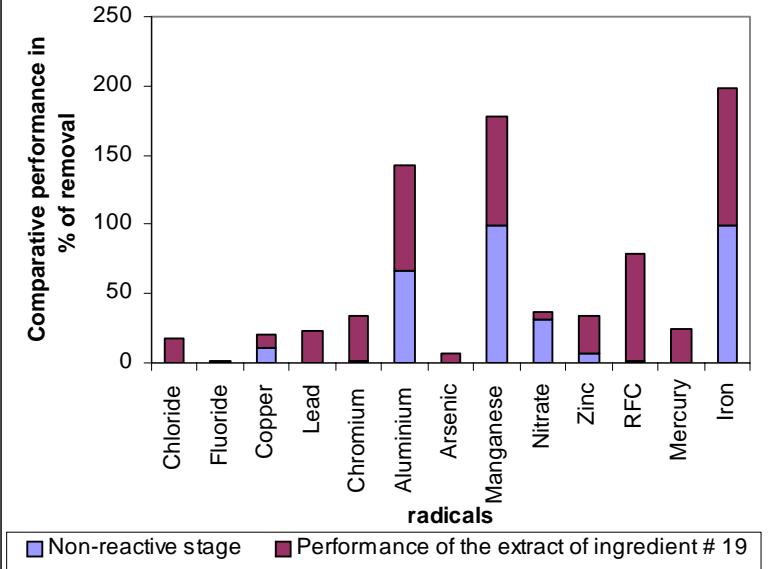


Annexure-4

Performance charts of ingredients against which(detoxication capacity) patent applications have been filed



Relative performance of the extract of coconut coir



Annexure-5

Copy of the press release on 15th November'05

PRESS RELEASE (15th November 2005)

VASUNDHARA(www.vasundharaorissa.org), a Bhubaneswar-based NGO working in the field of natural resource management since 1992, encountered problems relating to the availability of drinking water in one of its field areas in 2003-04, when it was found that chemical- and/or physical contamination in water (like, excess fluoride, etc.) was the source of the problem and the existing/available solutions were not sustainable at the level of rural poor either because these people lacked adequate technical knowledge to maintain things on their own, or the solution was comparatively costlier. This encouraged us to develop simple, low-cost and eco-friendly methods to provide a solution to this problem. Accordingly, the first phase of experiments was carried out in November 2004 with the analytical work done at the Regional Research Laboratory, Bhubaneswar on payment basis. This experiment came out with encouraging results(vide the report available at www.vasundharaorissa.org/Organicdetoxicationofwater.pdf), but it had some limitations(like, the results were applicable to water having a very low pH, i.e. under highly acidic conditions). To overcome these limitations, the second phase of experiments were carried out in July 2005 with several modifications in the experimental plan, and the results obtained this time are more useful under normal conditions as the pH of the final solution was kept around 6.

The objectives behind such experiments were multi-dimensional as explained under:

- ✱ To develop water detoxication process that would use chiefly local- or house-hold resources as the major detoxicating agent. This will help the people become self-reliant in the technique.
- ✱ To explore new markets for otherwise obscure forest products(like, Bahada), or those natural products which are struggling for a good market price(like, Sal seed or Pan leaves), through the discovery of new areas of utilization for them.
- ✱ To develop eco-friendly and herbal solutions for industrial pollution.
- ✱ To expand the utilization pattern of traditionally used ingredients (like, Nirmala seeds).
- ✱ To find clues that can be used for development of drugs for the treatment of diseases related to water toxicity, like arsenicosis, fluorosis, blue baby syndrome, etc..

Prof. Anil Gupta, the vice-chairperson of National Innovation Foundation, Govt of India was impressed to see these findings. He was also interested to see a collaboration between CSIR and VASUNDHARA to pursue this work for further development. VASUNDHARA is trying to implement his advice to patent atleast some of these discoveries, within its financial limitations, not for any commercial purpose but to protect out rights over the innovations. Since the primary objective was public benefit, hence we are disseminating most of the relevant information through this press conference so that various stakeholders worldover could know them and use accordingly. **It is important to note** that many of the underdescribed findings also have their limitations, but since the process is a flexible one and the ratio of toxicity versus detoxicating agent can be suitably modified, or even active principles (derivatives) can be obtained from the successful detoxicating agents for more specific purposes, hence the said limitations are not supposed to create any major problem. **We however request various research organizations in the public- as well as private sectors to scientifically validate the way in which these discoveries can be of best use for different stakeholders.**

VASUNDHARA's findings⁸:

A. Clues according to chemical parameters:

1. **Pentavalent Arsenic**: initial concentration 4.52 ppm; desirable 0.01⁹ ppm as per Indian standards for drinking water
 - **Boiled extract of Rasna(fresh plant of *Vanda tessellata*, all parts) removes pentavalent arsenic from water by 72.79%. No precipitation found.**
2. **Nitrate**: initial concentration 306.66 ppm; desirable 45 ppm as per Indian standards for drinking water):
 - Sunthi(dry ginger or *Zingiber officinale*) extract(prepared by soaking): removes nitrate by 55.24% (nitrite conversion limited to 2.92 ppm) without any precipitation. Sunthi also helps remove mercury and arsenic.

B. Clues according to agro-products or forest products:

1. Sal(*Shorea robusta*) seed(extract prepared by soaking):
 - **Chloride**(initial concentration 2655 ppm, desirable 250 ppm)- removal by 46.59%(slight precipitation)
 - **Aluminium**(initial concentration 4.52 ppm, desirable 0.03 ppm): 50% more removal than under normal conditions. No precipitation.
 - **Residual Free Chlorine**(initial concentration 17.86 ppm, desirable 0.20 ppm): removal by 98.71% with fine precipitation.
2. Mahul(*Madhuca indica*) flower (extract prepared by soaking)::
 - Removal of **Copper**(initial concentration 4.52 ppm, desirable 0.05 ppm): 41.59% (no precipitation)
 - Removal of **Nitrate**(initial concentration 306.66 ppm; desirable 45 ppm) - 48.66% (no precipitation; nitrite conversion limited to 4.62 ppm)
 - Removal of **Aluminium**(initial concentration 4.52 ppm; desirable 0.03 ppm): 50% more removal than under normal conditions (no precipitation)
 - Removal of **Mercury** (initial concentration 4.52 ppm, desirable 0.001 ppm): 50% (fine precipitation)

⁸ All extracts mentioned herein are aqueous in nature, and laboratory grade distilled water has been used for this purpose.

⁹ As mentioned earlier in the report, despite a recommendation for taking 0.01 mg/l as the desirable limit; the specification used practically has remained 0.05 mg/l. This clarification did not form a part of the original press release.

3. Bahada(*Terminalia bellirica*) fruit (extract prepared by soaking):
 - Removal of **Residual Free Chlorine**(initial concentration 17.86 ppm, desirable 0.20 ppm) by 94.23%(no precipitation unlike in case of Harida i.e., fruit of *Terminalia chebula*, also more effective than Harida)
 - Removal of **Mercury**(initial concentration 4.52 ppm, desirable 0.001 ppm): 58.52% (no precipitation unlike in case of Harida; also more effective than Harida)

4. Pan(*Piper betle*) leaves(boiled extract with negligible *haldi* just to change colour):
 - Removal of **Hexavalent Chromium** (initial concentration 4.52 ppm, desirable 0.05 ppm): 25.28% (slight precipitation)
 - Removal of **Mercury** (initial concentration 4.52 ppm, desirable 0.001 ppm): 51.79% (fine ppt.)
 - Removal of **Fluoride**(initial concentration 4.52 ppm, desirable 1 ppm) by 9.10% (no precipitation)

5. Kendu(*Diospyros melanoxylon*) leaf (extract prepared by boiling):
 - Removal of **Fluoride**(initial concentration 4.52 ppm, desirable 1 ppm): 10.18% (no precipitation)
 - Removal of **Lead**(initial concentration 4.52 ppm, desirable 0.05 ppm): 35.84%(no precipitation)
 - Pentavalent **Arsenic**(initial concentration 4.52 ppm; desirable 0.01 ppm) – 30.31%(no precipitation)

6. Nirmala(*Strychnos potatorum*) seeds(extract prepared by soaking):
 - Removal of **Lead**(initial concentration 4.52 ppm, desirable 0.05 ppm)-60.40% (no precipitation)
 - Removal of **Zinc**(initial concentration 4.52 ppm, desirable 5 ppm): 44.91%(no precipitation)
 - Removal of **pentavalent Arsenic** (initial concentration 4.52 ppm; desirable 0.01 ppm) 44.03%(no precipitation)

For clarifications contact Bikash Rath at bikash1968@gmail.com .

Thank you.
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