# द्विवार्षिक प्रतिवेदन

# BIENNIAL REPORT

## 2000 - 2002


केन्द्रीय नमक व समुद्री रसायन अनुसंधान संस्थान, भावनगर

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इस कार्य में संस्थान के सभी विभागाध्यक्षों से प्राप्त सहयोग के लिये आभारी हैं ।

The Mahatma who rocked the British Empire
&
galvanised the people
by defiantly gathering salt at the Dandi Seashore.
6th April 1930

“I do not wish any worker to come to these laboratories merely with the aim of earning his living. What I wish is that our young men and women who come here should have a zeal for working out problems which would have great consequence. That would give vitality to the these Institutes. They should realize that service to India - no, even to the whole world; science has no frontiers”.

Pandit Jawaharlal Nehru
Extract from the inaugural address on 10th April 1954

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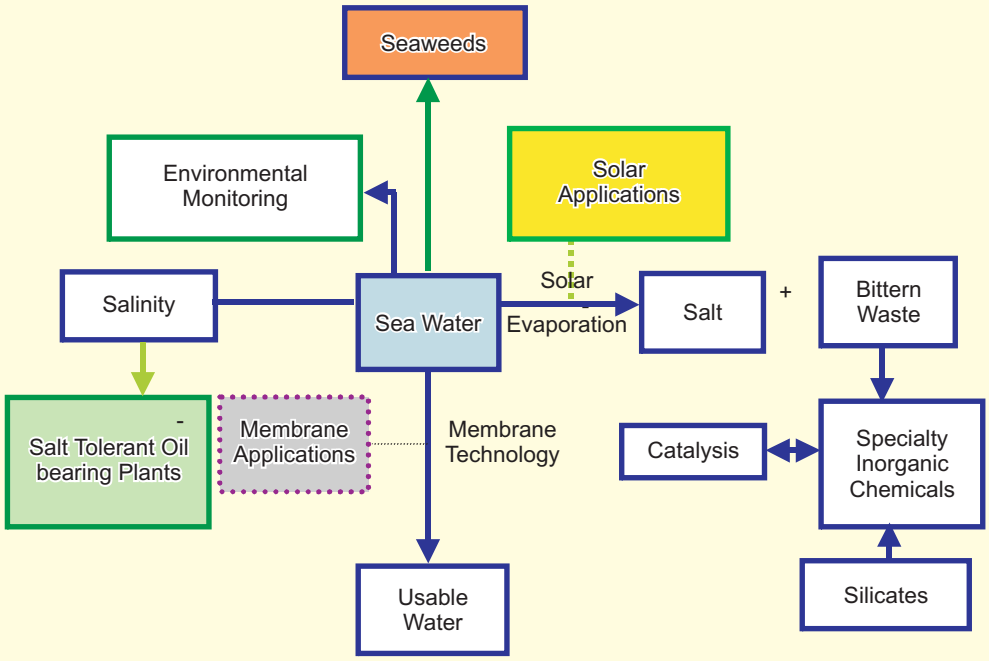
# CSMCRI AT A GLANCE




Schematic depiction of the activities of

CENTRAL SALT & MARINE CHEMICALS RESEARCH INSTITUTE

with seawater as the central theme

# FOREWORD

I have great pleasure in presenting the Report for the period 2000-2002. We have continued to pursue the goal of integrating all of the Institute's activities under the common theme of seawater research. This has helped identify some big goals and promote synergy among the disciplines. Our second area of focus has been on innovation and excellence. Our third area of focus has been on quick translation of concepts into practice. Our fourth area of focus has been on relevance, and we have enlisted the participation of industrial clients, even while undertaking projects supported by Grant-in-aid agencies. Our fifth area of focus has been societal responsibility and it has been gratifying to work closely with marginal producers of salt and see their income level rise. Our sixth area of focus has been on competency building and infrastructure development.

Scientists of the Institute won the CSIR Technology award in 2001 and 2002. It is gratifying that Pepsico India Holdings Ltd. has embarked on commercial cultivation of Eucheuma utilizing the Institute know how. It is also gratifying that NALCO's Zeolite A plant based on CSMCRI know how was commissioned successfully this year. Two of our scientists were awarded the prestigious Raman Fellowship, one in 2001 and one in 2002. The Institute maintained a healthy track record of publications, which, in 2001-2002, had the fourth highest 'average impact factor' within the CSIR group of laboratories. The Institute also filed a number of international patents in areas of direct relevance to the Institute's mandate. This is especially satisfying since we have been able to innovate in seemingly mature technologies.

The Institute is centralizing its analytical facilities, which will be housed in the new laboratory building whose construction has been completed. Several new instruments such as XRF, ICP-OES, Environmental SEM (with EDAX) and DSC-

TGA-DMA, have also been procured. Two new pilot plants are coming up in Mandapam field station (for production of bacteriological agar and carrageenan) and Experimental Salt Farm (for integrated recovery of marine chemicals). A new hostel has also been sanctioned to accommodate the growing number of project assistants.

I am grateful to all those who have lent their support to the Institute.

*Director*

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# अकार्बनिक रसायन

## नमक तथा समुद्री रसायन

हमारे देश में पोटाश की संपूर्ण आवश्यकता की पूर्ति (3 मिलीयन टन) आयात द्वारा की जाती है, इसलिये हमारे देश में सहजता से प्राप्त समुद्र से तथा भूमिगत ब्राईन से पोटाश की पुनः प्राप्ति के लिये व्यवहारिक प्रक्रिया विकसित करना अत्यावश्यक हो गया है । तदुपरांत हमारे देशमें साल्ट वर्क्स 14 मिलीयन टन नमक का उत्पादन करते हैं तथा सहउत्पाद्य बिटर्न जो पोटाश ब्रोमीन तथा मैग्नेशिया का स्त्रोत है – उसे समुद्र में प्रवाहित कर देते हैं, इसलिये इसका उपयोग करना इच्छनीय है । गुजरात के कच्छ का बड़ा–रन कुदरती बिटर्न का अमर्यादित स्त्रोत है जिसे पोटाश उत्पादन के लिये उपयोग किया जा सकता है । ब्राइन बाष्प से प्राप्त निम्न सोडियम कारनेलाइट से आर्थिक दृष्टि से मितव्ययी पोटाश का उत्पादन किया जा सकता है । फिर भी इच्छित शुद्वतावाले पोटाश के लिये सीधे डबल साल्ट के वियोजन लाभार्थ निम्नतम सोडियम वाले कारनेलाईट का उत्पादन से एक विकट कार्य है । हमारे देश के समुद्रों से प्राप्त बिटर्न तथा भूमिगत ब्राईन से उच्च सल्फेट युक्त आयन सांद्रता वाले ब्राईन के कारण काईनाइट टाइप के डबल साल्ट की अपरिवर्तनीय उपज होती है, और इस काईनाईट को उपचरित करके सर्वस्वीकृत पोटाश KCl (MOP) तथा पोटैशियम सल्फेट $K_2SO_4$ (SOP) की पुनःप्राप्ति करना जटिल कार्य है और संभवतः इन कारणों के रहते भारत में आजतक पोटाश की पुनःप्राप्ति के लिये किसी प्रौद्योगिकी का व्यापारीकरण संभावित नहीं हो सका । इस संस्थान ने पिछले दो साल के दौरान भारतीय परिप्रेक्ष्य में KCl तथा $K_2SO_4$ की पुनः प्राप्ति के लिये सक्षम प्रौद्योगिकी विकसित करने के लिये महत्वपूर्ण प्रगति की है ।

पहला अभिगम बिटर्न को सल्फेट विहिन करने की व्यवहारिक पद्वति निर्धारित करने का रहा । इस कार्य के लिये भूमिगत ब्राईन से प्राप्त बिटर्न का चुनाव किया गया क्योंकि समुद्री ब्राईन से प्राप्त बिटर्न की तुलनामें इसमें सल्फेट की मात्रा आधी होती है । इसके साथ $CaCl_2$ की क्रिया से सल्फेटविहिनीकरण का कार्य उत्तम रुप से और कम व्यय से संभव है । इसलिए इसके उत्पादन पर विशेष ध्यान दिया गया । सर्वप्रथम कार्य था चूना तथा HCl में से $CaCl_2$ का उत्पादन करना, और इसके लिये $CaSo_4$ कार्नेलाईट तथा $MgCl_2$ मैग्नेशियम क्लोराइड के उत्पादन की प्रक्रिया विकसित की गई । $MgCl_2$ $6H_2O$ से अतिशुद्वMgO के उत्पादन के दौरान सहउत्पाद्य के रुपमें HCl मिलता हैं इसलिये 2 कि.ग्रा./घण्टा की क्षमता पर ऐसी केल्सीनेशन प्रक्रिया द्वारा MgO उत्पादन कार्य का निर्देशन किया गया और HCl की पुनः प्राप्ति के लिये प्रयत्न जारी है (पेटेन्ट एप्लीकेशन No.PCT/IN01/00185 दिनांक 22 अक्तूबर 2001).

संस्थान ने कम व्यय पर $CaCl_2$ प्राप्त करने के स्त्रोत खोजने के लिये अनुसंधान कार्य जारी रखा और पाया कि सोड़ाऐश के उत्पादन के दौरान विलेयन प्रक्रिया से उत्पन्न विस्तृत प्रवाही इस कार्य के लिये विश्वसनीय है । नमक तथा सोडाएश का उत्पादन करने वाले निरमा केमीकल्स, सौराष्ट्र केमीकल्स, गुजरात हेवी केमीकल्स लिमिटेड और टाटा केमीकल्स जैसे अग्रणी उद्योग, जो अभी उच्छिष्ट तथा बिटर्न समुद्र में प्रवाहित करते हैं, उन्हें बिटर्न के साथ आसवन उच्छिष्ट के सल्फेटविहिनीकरण द्वारा पोटाश तथा अन्य समुद्री रसायनों की पुनः प्राप्ति में रुची है । भारत सरकार के महासागर विकास विभाग के सहयोग से, संस्थान इनमें से कुछ उद्योगो के साथ इस विषय में कार्यरत है ।

संस्थान ने, सल्फेटविहिनकरण द्वारा कार्नेलाईट के उत्पादन की पद्धति का उपयोग करके 100 कि.ग्रा. की क्षमता पर निम्न सोडियम सोल्ट (NaCl तथा KCl का मिश्रण) के लिये प्रक्रिया विकसित की है तथा इस के व्यापारीकरण के लिए एक उद्योग के साथ सक्रिय रुपसे कार्यरत है

(पेटेन्ट एप्लीकेशन *No.* PCT/IN02/00018 दिनांक : 31-03-2002) संस्थान ने पहली बार बड़े पैमाने पर <1% NaCl अशुद्वतावाले कार्नेलाईट के उत्पादन की प्रक्रिया सफलतापूर्वक विकसित की है । परिणामस्वरुप कोल्ड प्रोसेस द्वारा >98% शुद्वतावाले KCl का उत्पादन संभव हुआ है (पेटेन्ट फाईल करने की प्रक्रिया जारी है)। दूसरा अभिगम $32^0$ पर बिटर्न को उपचरित करके सल्फेटविहिन करने की प्रक्रिया पर आधारित है और इस प्रक्रिया द्वारा प्रयोगशाला स्तर पर KCl उत्पादन के लिये निम्न सोडियम साल्ट, $MgCl_2$ घोल तथा शुद्वप्रवाही पर भी परीक्षण किये गये ।

अत्यंत परिष्कृत, औद्योगिक स्तर के नमक के उत्पादन के लिये ब्राईन के सल्फेटविहीनीकरण के इस महत्वपूर्ण नवीन अभिगम ने असंख्य उद्योगों का ध्यान आकर्षित किया है । (पेटेन्ट एप्लीकेशन *No. PCT/INO1/00185* दिनांक 22 अक्तूबर 2002). ब्राईन में स्थित सल्फेट की अशुद्वता से मैग्नेशियम तथा केल्शियम (सल्फेट साल्ट के रुपमें) की मात्रा में वृद्धि होती है और इसी ब्राईन से साधारण नमक तैयार किया जाता है । सोडाऐश तथा कास्टिक सोडा का उत्पादन करने वाले उद्योग नमक की शुद्धता बढाने के लिये प्रयत्नशील हैं और इसकार्य में उन्हें जितनी सरलता होती है वह उनके लिये लाभदायी है । उच्चत्तम गुणवत्ता वाले औद्योगिक नमक से अगरियाओं की आय में भी वृद्धि होगी ।

सल्फेटविहीनीकरण पद्वति द्वारा नमक की गुणवत्ता में सुधार ने समुद्री रसायनों की संमाकलित (इन्टीग्रेटेड) पुनःप्राप्ति के कारण यह प्रौद्योगिकी अपनेआप में महत्वपूर्ण एवं आकर्षक है तथा कई कंपनियों ने इस प्रक्रिया में अपना रस दर्शाया है । प्रायोगिक साल्ट फार्म में गत वर्ष नमक उत्पादन के दौरान 100 टन स्केल पर नमक उत्पादन की यही प्रक्रिया अपनाई गई थी ।

यद्यपि पहले कार्नेलाईट द्वारा पोटाश की पुनःप्राप्ति की पक्रिया का विशेष रुप से उल्लेख किया गया है, और नमक की गुणवत्ता के सुधार के समय समुद्री रसायनों की समाकलित पुनःप्राप्ति के अंतर्गत इसकी क्षमता दर्शायी गई है लेकिन इस अभिगम द्वारा पोटाश का उत्पादन 2-3 लाख टन से ज्यादा संभव नहीं है। (एक लाख टन नमक उत्पादन के दौरान सह–उत्पाद्य के रुप में प्राप्त बिटर्न से 1200 टन पोटाश का उत्पादन किया जा सकता है)। हालांकि इसकी आवश्यकता बहुत ज्यादा है। दूसरी ओर कच्छ के बड़ा–रन में कुदरती बिटर्न विपुल मात्रा में प्राप्त है, लेकिन सिर्फ KCl के उत्पादन के लिये इसका सल्फेटविहीनीकरण करना व्यवहारिक नहीं है । फिर भी ब्रोमीन उत्पादन के साथ संकलित रुप में इसका उत्पादन कुछ हद तक संभव है । विशेषतः कृषि विशेषज्ञों के अनुसार बिटर्न में स्थित सल्फेट का उचित उपयोग SOP के उत्पादन में किया जाना चाहिए जो MOP से श्रेष्ठ माना जाता है लेकिन इसका उपयोग कम होने का कारण इसकी दोगुनी कीमत हैं। यह ध्यान में रखते हुए, कारनाईट मिश्रित नमक में MOP मिलाकर 94% शुद्व $K_2SO_4$ के उत्पादन के लिये संभवित प्रयास किये गये । इस प्रौद्योगिकी की विशेषताएं हैं : (i) कोल्ड प्रोसेस द्वारा $K_2SO_4$ का उत्पादन (ii) कारनाईट मिश्रित नमक को उपचरित करने के लिये MOP के अलावा अन्य किसी रसायन की आवश्यकता नहीं (iii) 1Kg MOP मिलाने से 1.5 Kg $K_2SO_4$ का उत्पादन किया जा सकता है । इस संशोधन से MOP की आयात 35% कम की जा सकेगी, साथ ही साथ भारतीय कृषकों को SOP की अंतर्राष्ट्रीय कीमत से कम कीमत पर उत्तम उर्वरक उपलब्ध कराया जा सकेगा ।

समुद्री रसायनों की पुनःप्राप्ति के लिये प्रभाजी (फ्रेकशनल) स्फटीकीरण के परंपरागत अभिगम के उपरांत, संस्थान ने ब्राईन/बिटर्न से चयनित रसायण पोटाश ($K^+$) की पुनःप्राप्ति के लिये उचित निष्कर्षक भी विकसित किये हैं । हमने बिटर्न से सिर्फ पोटाश के निष्कर्षण के लिये नोर्शक हाईड्रो के प्रस्ताव अनुसार समुद्रीजल से डाइपीक्रीलेमाइन के साथ पोटाश की पुनःप्राप्ति के लिये मूल अभिगम अपनाया, डाइपीक्रीलेमाईन को पहले चूने के साथ उपचरित किया गया और उचित अनुपात (स्टोइकोमेट्रिक) में बिटर्न में मिलाया गया, जिससें तत्काल लाल अवक्षेपित प्राप्त हुआ । अवक्षेपित को नाइट्रिक एसीड के साथ उपचरित करने से शुद्ध पोटैशियम नाइट्राईट प्राप्त हुआ और डाइपीक्रीलेमाईन का पुनः उपयोग किया जा सका ।

जैसा कि उपर दर्शाया गया है कि नमक का औद्योगिक उपयोग विशेषतः उसमें प्राप्त कैल्शियम अशुद्वियों की मात्रा पर निर्भर करता है । ब्राईन से कैल्शियम की अशुद्वियाँ दूर करने के लिये समुद्री सायनोबैक्टेरिया का उपयोग करने की एक नवीनतम प्रौद्योगिकी विकसित की गई है । इस संवर्ध (कल्चर) ने 9 $Be^0$ से 29 $Be^0$ विभिन्नतावाले समुद्रीतथा भुमिगत ब्राईन संयोजनो के लिये अच्छी अनुकूलक्षमता दर्शायी है । 42 घण्टे के सायनोबैक्टेरिया कल्चर ने ब्राइन से कैल्शियम एकत्रित करने में उत्तम क्षमता दर्शायी ओर इससे 48 घण्टे में ब्राईन से महत्तम 80% कैल्शियम सांद्रण दूर किया गया । यह प्रक्रिया फील्ड पर (100 की.ग्रा.स्केल) कार्यरत है और भूमिगत ब्राईन से उत्पन्न नमक से लायंब्या एस्तुएरी के साथ 24>$^0$ Be पर उपचरित करने पर 50% कैल्शियम कम किया गया (यु.एस. पेटेन्ट एप्लीकेशन *No.09/777664* दिनांक 2 जुलाई 2001)। यह प्रक्रिया एक पर्यावरण सहयोगी जैववैज्ञानिक प्रक्रिया है जिसके परिचालन में अतिरिक्त रसायन और उर्जा की आवश्यकता नहीं रहती । उच्च घनत्व वाले ब्राईन में प्लवन बायोमास अत्यंत हरे रंगकी जालीदार रचना के कारण ब्राइन से पानी के बाष्पीकरण दर में वृद्धि की जा सकी लेकिन अभी इसका परीक्षण बाकी है ।

## ब्राईन घनत्व को दूर से नापने का यन्त्र

साल्ट वर्क्स में ब्राईन का घनत्व दूर से ही नापने के लिये एक आविष्कृत यन्त्र डिज़ाईन और विकसित किया गया, और पोर्ट विक्टर के एक बड़े साल्ट फार्म में इसका परीक्षण किया गया ।

इस यन्त्र को इस तरह से बनाया गया है कि कम घनत्व पर यह डूब जाता है तथा 25.5$^0$Be पर तैरता है, जिससे नमक विनिर्माता दूर से ही ब्राइन का वास्तविक घनत्व जान सकता है, जिस पर संघटित ब्राइन को नमक स्फटिकीकरण के लिये स्फटिकीकरण के पात्र में डाला जाता है । यह यन्त्र आवेशित ब्राईन घनत्व को नियंत्रित करने तथा नमक की गुणवत्ता सुधारने में मदद करता है ।

## बांग्लादेश से प्राप्त नमक का उन्नयन

बांग्लादेश से प्राप्त सौर्य नमक के उन्नयन के लिये, 5 टन प्रतिघण्टा की यांत्रिक नमक धुलाई की क्षमतावाले यंत्र की सम्बद्ध जानकारी मेसर्स न्युवर्ग इन्जीनियर्स प्राईवेट लिमिटेड, नोईडा को दी गयी । 83-84 % सोडीयमक्लोराईड युक्त कच्चा नमक 98.5% सोडीयमक्लोराईड युक्त तक शुद्ध किया गया ।

विकसित धुलाई प्रक्रिया द्वारा 80 प्रतिशत से भी ज्यादा कैल्शियम तथा मैग्नेशियम अशुद्धियाँ एवं अघुलनशील पदार्थो को दूर किया जा सका । यह उन्नयन प्रक्रिया बांग्लादेश में कास्टिक सोडा संयत्र लगाने में सहायक होगी ।

## सामाजिक एवमं आर्थिक लाभ के लिये सॉल्ट क्लस्टर का विकास

सी.एस.एम.सी.आर.आई तथा सेवा (सेल्फ एम्पलायमेन्ट विमेन एसोसीएशन) अहमदाबाद ने, कच्छ के छोटे रन में छोटे और बडे साल्ट वर्कस (अगरिया) द्वारा उत्पादित नमक की गुणवत्ता तथा क्षमता में सुधार लाने के उद्देश्य से संयुक्त कार्यक्रम शुरु किया है । प्रथम चरण में सेवा तथा सी.एस.एम. सी.आर.आई. ने 35 बड़े साल्ट वर्कस द्वारा किये जानेवाले नमक उत्पादन की गुणवत्ता में सुधार करने का कार्य किया । नमक उत्पादन तथा गुणवत्ता में सुधार लाने की उच्चतर प्रक्रिया के बारे में अगरियाओं को प्रशिक्षण दिया गया । संस्थान द्वारा इस प्रकार की तकनीकी सहायता के कारण बहुत सारे अगरिया लोग औद्योगिक स्तर के नमक का उत्पादन करने में सक्षम हुए और SEWA द्वारा इसका उपयोग करनेवाले उद्योगों को बेचा। सोल्ट कल्स्टर विकास योजना के अंतर्गत SEWA तथा सी.एस.एम.सी.आर.आई. ने कच्छ के छोटे–रन के दूसरे साल्ट वर्कस को समाकलित रुपसे अन्य मूल्य वृद्धिवाले समुद्री रसायनों की पुनःप्राप्ति के साथ औद्योगिक नमक के उत्पादन के लिये सहायता करने का प्रस्ताव रखा है ।

## साल्ट वर्कस रुपरेखा – सरंचना

वलसाड जिले के धरासना गांव में समुद्री ब्राईन से औद्योगिक स्तर के नमक उत्पादन के लिये 10 एकड़ के साल्ट वर्कस की रुपरेखा बनाने की संरचना तैयार की गई । यह योजना रुरल टेकनोलोजी इन्स्टीटयुट आफ गुजरात (ग्रामीण प्रोद्योगिकी संस्थान, गुजरात) द्वारा प्रायोजित की गई । इस साल्ट वर्कस में <0.1 कैल्शियमवाला औद्योगिक स्तर का नमक उत्पादित किया गया ।

## जिप्सम का विकास

साल्ट वर्कस में नमक उत्पादन के समय यांत्रिक धुलाई द्वारा कच्चे जिप्सम स्फटिकों से सीमेन्ट ग्रेड का जिप्सम बनाने की प्रक्रिया विकसित की गई । धुलित जिप्सम विश्लेषण करने पर <0.5% क्लोराईड की सीमेन्ट ग्रेड की विशेषतावाला पाया गया । साल्ट वर्कस द्वारा अपनायी गई सल्फेटविहीनीकरण पद्वति से एकबार ही में विपुल मात्रा में समुद्री जिप्सम की प्राप्ति के कारण इस का महत्व विशेष है ।

## आयोडीकृत नमक में आयोडेट की स्थिरता

मेसर्स हिन्दुस्तान लीवर लिमिटेड, मुंबई द्वारा उत्पादित सुधारित नमक में आयोडेट की स्थिरता का त्वरित एवं संचायक परिस्थितियों में अभ्यास किया गया । इन परीक्षणों के फलस्वरुप ज्ञात हुआ कि नमक में आयोडेट स्थिरता में उल्लेखनीय सुधार हुआ है ।

## आयोडीन का परीक्षण करने के लिये किट

फील्ड़ में आयोडीकृत नमक में आयोडीन का परीक्षण करने के लिये एक प्रक्रिया विकसित की गई । यह नवीन पद्वति आयोडीकृत नमक में संभवित मिलावट का परीक्षण करने में सक्षम है संस्थान द्वारा युनिसेफ के लिये ऐसी 200 किट तैयार की गई ।

## नमक के आयोडीकरण के लिये उच्च शुद्धतावाला पौटैशियम आयोडेट द्रव

साल्ट वर्कस में ही नमक को आयोडीकृत करने के लिये उचित सांद्रतावला तथा उच्च शुद्धतावाला पोटैशियम आयोडेट द्रव सतत तैयार करने हेतु आयन विनिमय झिल्ली पर आधारित एक सरल विद्युत रसायनिक प्रक्रिया विकसित की गई । परिणामस्वरुप पोटैशियम आयोडेट निर्माण की प्रक्रिया विकसित की जा सकी जिससे नमक के आयोडीकरण का खर्च भी कम हुआ ।

## सिलिकेट्स तथा उत्प्रेरण

### त्रिविम चयनित इपोक्सी – सेतु अणुओं का संश्लेषण

डायजोमीथेन या मीथेनसल्फोनिलाजाइड से, विभिन्न लम्बाइयो वाले विस्थापित साइक्लोपेन्टानोन तथा साइक्लोहेक्सानोन के साथ पगही समान बंधित, कई डायजोकार्बोदित यौगिकों का संश्लेषण किया गया । रोह्डियम II द्वितीय के साथ इन यौगिकों ने काबोनिल एलाईड द्विध्रुव के पांच या छे वलयी चक्र दिये । इन अस्थायी क्षणिक माध्यमिको का विस्थापित / अविस्थापित इनडोल, p - क्विनोन तथा सममित / असममित पेन्टाफुलवीन के साथ सुगम 1,3 – द्विध्रुवीय चक्रीय जुड़न हुए जिसने अनेक नवल इपोक्सी–सेतु बहुचक्रीय दिये । डेकाहाईड्रोबेन्जो [c] कार्बाजोल्स 1, डेकाहाईड्रोबेन्जो [a] कार्बाजोल्स 2, आक्सोटेट्रासाइक्लो $[6.5.1^{1,6}.0^{9,13}]$ टेट्राडेकीन 3 तथा कई इपोक्सी–सेतु बहुचक्रीय रुचिकर संरचना वाले अणु (जैसे 4,5) संश्लेषित किये गये । असामान्य चक्रीय उत्पादन ट्राई–आक्सोपेन्टासाईक्लिक 6 का भी संश्लेषण तथा चरित्रण किया गया । अस्थायी पांच तथा छे सदस्यीय वलयी कार्बोनिल एलाईड बनाने का प्रदर्शन भी किया गया । कई नये कार्बनिक अणुओं के संश्लेषण हेतु टैन्डम चक्रण – चक्र जुड़न विधि का विकास किया गया । चार काईरल केन्द्रो तथा दो कार्बन–कार्बन बंधो को एक संश्लेषित चरण में बनाने के लिये यह प्रक्रिया विशेषरुपेण आर्कषक है ।

### ठोसावस्था अति–आणुविक संरचनाएं

स्फटिक अभियान्त्रिकी का ध्येय, अ–बंध अन्योन्य क्रियाओं जैसे हाईड्रोजन–बंधन, ।।–।।स्तंभन तथा हैलोजन–हैलोजन अन्योन्यन को समझकर, अति–आणुविक पदार्थो के युक्तिसंगत नमूने बनाना है । हाल के वर्षो में यह महसूस किया गया कि धातु–लिगेन्ड के अन्योन्य क्रिया से उप सह संयोजन बन्धो का बनना भी अति–आणुविक समुच्चयो को बनाने के लिये एक व्यापक उपगमन है ।

कैम्ब्रिज स्ट्रक्चरल डेटाबेज से इक्टठी की गई सूचनाओं के आधार पर बनाने वाले ब्लाकों को चिपकाने वाले मोटिफ्सो की पहचान की गई । संस्थान के कार्य में, 4,4 बाईपिरीडीन जैसे दृढ बंधक के साथ एक Co(II) उपसहसंयोजन बहुलक बनाकर उसका संरचनात्मक चरित्रण किया गया । बहुलक में 2-D वर्ग ग्रिड संरचना है, जिसमें उप सहसंयोजक बंध तथा N-H . . .OH बंध दोनों की अन्योन्य क्रिया हैं । कार्बनिक लवण पर आधारित, एक द्विविमीय हाईड्रोजन–बंधित नेटवर्क का चरित्रण भी एकल X किरण विवर्तन तकनीक द्वारा किया गया ।

### अकार्बनिक धातु संकुल

- द्विनाभिकीय धातु संकुल, धातु – धातु संकुल अंतः क्रिया पर सेतु बंधन लिगेन्ड सम्मिलन (इनक्लुज़न) के प्रभाव के बारे में अन्वेषण करने के उद्देश्य से नये लिगेन्ड – 4 (3-4-डाईहाईड्रोक्सी बेन्जीन) का संश्लेषण किया गया । डाइफिनाइल पोरफाइरिन के नये सममित्तीय रुपसे प्रस्थापित, (ट्रान्स) बिस केटेकोलेट व्युत्पन्नों का फिनाईलपोरफाइरीन के एकल प्रस्थापित केटेकोलेट व्युत्पन्नों के साथ संश्लेषण किया गया तथा गुणधर्मो का परीक्षण किया गया । तदनुसार रुथेनियम (2-2 bipy)$_2$ $(Sq)^+$ (Sq = सेमीक्विनोन) के एक तथा द्वि–नाभिक संकुलो का भी संश्लेषण किया गया एवं गुणधर्मो का परीक्षण किया गया । अतिथि के रुपमें नाइट्रोबेन्जीन के साथ ZnTPP का सम्मिलन संकुल भी संश्लेषित किया गया तथा एकल क्रिस्टल एक्स–रे संरचना हल की गई ।

- 2-4-6- ट्रिस (2-पिरिडिन) 1-3-5 ट्रायाजीन लिगेन्ड का उपयोग करके रुथेनियम (II) तथा ओस्मीयम (II) के हेट्रोडाइन्युक्लीयर संकुल तैयार किये गये । डिज़ाईन किये गये श्रेणीबद्ध पौलिपिरिडिल आधारित सेतु बंधन लिगेन्ड के साथ रुथेनियम (II) तथा ओस्मीयम II के एकल, द्वि, तथा चतुर्थ नाभिक, सम/विषम धातु संकुलो के अवदीप्ति प्रकाशीय गुणधर्म का विभिन्न प्रायोगिक अवस्थाओ में अध्ययन किया गया । इन सभी संकुलो के क्वान्टम प्राप्ति की गणना की गई । उक्त अवदीप्त विवरणों से ज्ञात हुआ कि सेतुबंधक लिगेन्ड द्वारा हेट्रोन्युक्लियर संकुलो में रुथेनियम (II) से ओस्मीयम II केन्द्र में आंतर्आण्विक ऊर्जा रुपांतरण होता है ।

- उत्प्रेरण के लिये संक्रमण धातु आधारित संकुलो का संश्लेषण, मूल्यांकन तथा उनके गुणधर्मो का परीक्षण किया गया । $Co^{2+}$ तथा $Cd^{2+}$ के साथ मोनोन्युक्लियर संकुल तैयार किये गये तथा उनके गुणधर्मो का परीक्षण कार्य प्रगति में है । डाईमेरीक ZnTPP आधारित बिल्डींग ब्लाक के सम्मिलित संकुल नाईट्रोबेन्जीन जैसे अतिथि ध्रुवीय के साथ तैयार किया गया तथा $^1$H NMR तथा सिंगल क्रिस्टल एक्स–रे द्वारा, गुणधर्मो का परीक्षण किया गया ।

## उन्डीन तथा 6 साइनोक्रोमीन का धातु संकुलो के साथ काईरल इपोक्सीकरण

0-4$^0$ से. तापमान परास में, पिरीडीन ओक्साईड (2-10 मोल %) को अक्षीय क्षारके रुपमें तथा हाइपोक्लोराईट को आक्सीकारक के रुपमें लेकर, 1 उत्प्रेरक (0.5-2 मोल %) का उपयोग करके इन्डीन का 10 ग्राम के स्तर पर तथा 6- साइनोक्रोमीन का 5 ग्राम के स्तर पर काईरल ईपोक्सीकरण किया गया ।

इस प्रक्रिया में प्रयुक्त उत्प्रेरक, जेकोबसन काइरल ईपोक्सीकरण उत्प्रेरक Mn (III) सेलेन में संशोधन करके बनाया गया था इस संशोधित उत्प्रेरक की मुख्यतायें हैं – (I) इस संशोधित उत्प्रेरक में निहित कला परिवर्तन (फेज ट्रान्सफर) क्षमता के कारण, इस की प्रतिक्रिया का दर 5 से 10 गुना तेज़ है, (II) सस्ते, अक्षीय के रुपमें प्रयुक्त किये जानेवाले पिरीडीन N ओक्साईड तथा 1-4 डाईओक्सेन, जैसे सह उत्प्रेरकों की उपस्थिति में हमारे उत्प्रेरक विशेष रुपसे कार्यक्षम पाये गये, जबकि मूल जेकोबसन उत्प्रेरक मे, मंहगे 4 फिनोइल पिरीडीन N ओक्साईड अथवा 4 (4-फिनाइल प्रोपाइल) पिरीडीन N ओक्साईड का उपयोग करना पड़ता था और (III) इन उत्प्रेरकों को 5 बार पुनःउपयोग में लिया गया, फिर भी इन की कार्यक्षमता में बहुत ही नगण्य कमी पाई गई, और (IV) उच्च परिवर्तनशीलता और सायनोक्रोमीन की प्रकाशीय शुद्धता 97% से भी ज्यादा पाई गई ।

(1R, 2R) साइक्लोहेक्जेन डायामीन के मोनो टारटैरेट से व्युत्पन्न डायमेरिक होमोकाइरल Mn (III) तथा Ni (II) शिफ़ क्षार संकुलो के साथ 3-5 डाई – टर्शियरी ब्युटाईल सैलिसलडिहाइड और 3- टर्शियरी ब्युटाइल, 5-5 मीथीलीन–बिस– सैलिसलडिहाइड को संश्लेषित किया गया और उर्त्सग अपचायक आईसो – ब्युटाईरलडिहाइड की उपस्थिति में, ओक्क्षोन और आण्विक ओक्सीजन को आक्सीकारक के रुप में उपयोग करके क्रोमीन्स, इंन्डीन, स्टाइरीन, t - 3 नोनीन और t – 4 ओक्टीन के प्रतिचयनशील इपोक्सीकरण के लिये उक्त संकुलों का उत्प्रेरक के रुप में उपयोग किया गया । सभी अल्कीनों मे संख्या सामीप्य परिवर्तन पाये गये तथा नाईट्रो और साइनोक्रोमिनो में उच्च काईरल इन्डकशन प्राप्त किया गया ।

इपीक्लोरोहाईड्रीन, स्टाईरीन आक्साईड तथा प्रोपीन आक्साईड के हाईड्रो काइनेटिक वियोजन के लिये डाईमेरीक Co (II) संकुल का उपयोग किया गया । उत्प्रेरक ने शुद्ध प्रतिचयनशील इपोक्साईड्स की अच्छी परिवर्तनशीलता दी।

(अ) समावयवीकरण अभिक्रियायें :

लौंगीफोलीन का व्यापारिक स्तर पर आईसोलोंगीफोलीन में समावयवीकरण सल्फ्युरिक एसिड द्वारा किया जाता है । संस्थान ने, आर.आर.एल. जम्मू के सहयोग द्वारा ठोस एसिड आधारित उत्प्रेरक विकसित किया है, जिसने विलायक रहित अवस्था में वातावरण के दबाव पर तथा $150^0$ सेंन्टिग्रेड तापमान पर 96% परिवर्तनशीलता दिखाई है । इस नये प्रविधि का लाभ अभिक्रिया–निहित कार्य को आसान करना है।

(ब) एसाइलीकरण अभिक्रियायें :

वर्तमान आईसोब्युटाइल बेन्जीन के एसाइलीकरण के लिये HF अथवा $AlCl_3$ का उपयोग करके, पर्यावरण मित्र उत्प्रेरक विकसित करने के उद्देश्य से संशोधन किया जा रहा है । 4 आईसोब्युटाइल एसिटोफीनोन के साथ 32% परिवर्तन तथा 92% चयनशीलता वाला, ज़ियोलाइट आधारित उत्प्रेरक व्यापारिक, उपलब्ध जियोलाईट को संशोधित करके, विकसित किया गया । प्राप्त उत्पादकता पहले की रिपोर्टो से ज्यादा पाई गई ।

वेरेट्रोल के लिये 90% से ज्यादा परिवर्तन तथा एनीसोल के लिये 65% से ज्यादा परिवर्तन देने वाले जियोलाईट तथा कार्बोदित मिट्टी आधारित उत्प्रेरक विकसित किये गये । यह प्रक्रिया विलायक विहीन है, तथा इसमें बगैर जोखिमवाले एसीलेटिंग एजन्ट का उपयोग किया गया जिसमें उच्च परमाणु मितव्ययिता है ।

जकोनिया तथा टिफ्लेट्स आधारित नैनो स्फटिक ठोस सुपर अम्लों के संश्लेषण के प्रयत्न किये जा रहे हैं । 8nm तक, निम्न स्फटिक माप तक सल्फेटी कृत जर्कोनिया, सोल–जेल विधि द्वारा बनाकर एसाइलीकरण में इसकी अभिक्रिया जांच जारी है ।

## अल्कीनों का हाइड्रोफार्मिलेशन

प्रोप्रांइलीन तथा 1 हेक्जीन के हाइड्रोफार्मीलेशन के लिये बनाये गये रुथेनियम तथा रोह्डियम धातु आधारित संकुलो के मूल्यांकन करने के लिये प्रारंभिक प्रयोग किये गये, जिसमें इन संकुलो ने चयनित N-एलडिहाइड बनाने के उत्साहवर्धक परिणाम दिखाये ।

## बेन्जीन का हाइड्रोजनीकरण तथा सल्फर का उत्प्रेरण सक्रियता पर प्रभाव

बेन्जीन के हाईड्रोजनीकरण के लिये धातु–संशोधन मिट्टी का संश्लेषण किया गया । उत्प्रेरक ने उच्च ताप तथा दाब पर 100 प्रतिशत परिवर्तन दिखाया लेकिन यह उत्प्रेरक सल्फर यौगिकों के साथ अति सुग्राही पाया गया तथा 10-100 ppm वाले थाओफीन की उपस्थिति में निष्क्रिय हो गया । उत्तरगामी संशोधनो में और अधिक थायोफीन सह्य उत्प्रेरक बनाये गये तथा उच्चतर सल्फर सह्यता के कारण की जांच जारी है ।

## अधिक सफेदी देनेवाले उन्नत डिटरजेन्ट ग्रेड ज़ियोलाईट – A का निर्माण

एन.आर.डी.सी द्वारा जियोलाईट – ए की मेसर्स नाल्को भुवनेश्वर को दी गई टेकनोलोजी के उत्पाद में, अधिक सफेदी लाने का संशोधन करके सफलतापूर्वक उन्नयन किया गया ।

बाक्साईट–लिचेट आधारित 10,000 टन प्रतिवर्ष का प्लान्ट लगाया गया तथा अन्तर्राष्ट्रीय बाजारों के उत्पाद की विशिष्टताओं से इस प्लान्ट से प्राप्त उत्पाद की तुलना की गई ।

## हवा में से आक्सीजन, नाईट्रोजन तथा आरगन अलग करने के लिये नवल अधिशोषक

हवामें से आक्सीजन, नाईट्रोजन तथा आरगन अलग करने के लिये नवल ज़ियोलाईट आधारित अधिशोषक विकसित किया गया । जिसकी तकनीकी विशेषताएं निम्न हैं ।

- $N_2$ के लिये उच्च अधिशोषण क्षमता – अब तक रिपोर्ट किये गये उत्तम क्षमतावाले समान ज़ियोलाईट की तुलनामें 1.5 गुना ज्यादा ।
- नाईट्रोजन के लिये लगभग 3 गुना ज्यादा चयनता ।
- प्रथम ज़ियोलाईट आधारित अधिशोषक जिसने आक्सीजन से अधिक आरगन के लिये चयनशीलता दिखाई ।

इस अधिशोषक के बनाने की प्रक्रिया के लिये एक – PTC पेटेन्ट फाईल किया गया।

## मसाले से मैली रसोई टाइलो की स्वतः सफाई के लिये प्रकाश उत्प्रेरकीय सक्रिय सतह

बंधक कोलायडल सिलिका, ज़ियोलाईट एक्स तथा मिट्टी द्वारा सिरेमिक टाइल्स पर $TiO_2$ का आवरण छंटकाव तकनीक द्वारा किया गया । चिपके हुए दाग का परीक्षण हलके आघात द्वारा तथा पानी से धोकर किया गया और देखा गया कि (1) सिर्फ $TiO_2$ (2) सिलिका + $TiO_2$ आवरित सतह दोनों में स्थिर रहा । आवरित टाइल्स पर रंग, मिर्ची, हल्दी तथा तेल को विभिन्न अनुपातो में मिलाकर दागों पर फलोरोसेन्ट प्रकाश में अनेक प्रयोग किये गये, परीक्षण से पता चला कि रंग के दाग 4 घण्टों में दूर हुए । जबकि मसाले के दाग 10-12 घण्टों में दूर हुए ।

## उपउत्पाद कैल्शियम कार्बोनेट के उपयोग की प्रक्रिया

उपउत्पाद चूना (10 कि.ग्रा / घण्टा) की प्रक्रिया से रबर ग्रेड तथा पीवीसी केबल इन्स्युलेशन ग्रेड का कैल्शियम कार्बोनेट बनाने के लिये बैंच स्तर का एक एकम तैयार करके संस्थान में स्थापित किया है ।

कान्टीन्युअस स्टरिड टेन्क रिएक्टर (CSTR) तथा बबल कॉलम रिएक्टर (BCR) की डिज़ाईन तैयार करके, विविध प्राचल नापने के लिये व्यवस्था की गई । सतहीं गैस का वेग (घण्टा / दिन) तथा कार्बोनेशन – समय की अधिकतम सीमा के लिये बबल कॉलम रीएक्टर में कुछ प्रयोग किये गये । सतह गैस की गति तथा प्रतिक्रिया समय / घण्टा / दिन / ओक्सीजन के उपयोग के बीच संबंध स्थापित किये गये । इच्छित कण–कद विभाजन तथा स्फटीकीयता वाला अवक्षेपित कैल्शियम कार्बोनेट बनाने के लिये प्रक्रिया को उच्चतम किया गया । बहुलीकरण तथा कण –कद विभाजन पर शक्कर, युरिया जैसे मिलावटों, तथा सरफेकटन्ट का असर देखा गया । जिससे कार्बोनेशन के दौरान ही केलसाईट बन गया और मिलावटों से कण का कद बढ़ गया ।

पीसीसी उत्पाद का उपयोग करके आवश्यक विशेषताओं वाले पी.वी.सी पाईप बनाये गये । पीसीसी में दंतमंजन तथा रंग के लिये आवश्यक विशेषताएं भी मिली हैं ।

## प्रयुक्त सिलिका से पैलेडियम की पुनःप्राप्ति

सिलिका कुछ पैलेडियम थैलोसियानीन संकुलों को शुद्ध करने में प्रयुक्त होती है । अंशतः संकुल अपरिवर्तनीय बंधित होता है जिससे पुनः प्राप्ति मुश्किल होती है । उच्छिष्ट सिलिका जेल से पैलेडियम की पुनः प्राप्ति को उत्तम करने हेतु, स्ट्राईड एक्रोलेब लिमिटेड बैंगलोर के लिये प्रक्रिया विकसित की गई ।

विस्तृत प्रयासो से Pd ($PdCl_2$ के रुप में) तीन चरणों की प्रक्रिया में 95% से अधिक, 99% शुद्ध तथा उच्छिष्ट रहित पाया गया । इस प्रक्रिया को 10 कि.ग्रा. की क्षमता तक विकसित करके टी.डी. आई.संयत्र, पार्टी को सफलतापूर्वक प्रदर्शित किया गया ।

## टी.डी.आई. संयत्र में उत्पादित बहिस्त्रावों के उपचार पर साध्यता अध्ययन

TDI उत्पन्न करने के लिये डाईनाइट्रोटालुइन (DNT) तथा मेटाटालुइन डाईअमीन (MTD) माध्यमिकों का उपयोग किया जाता है । द्रवित उच्छिष्ट, जिसमें प्रयुक्त खनिज अम्ल तथा कार्बनिक यौगिक होते हैं उसको $1100^0C$ तापमान पर अभी भस्मीभूत किया जाता है, । COD को स्वीकार्य स्तर तक लाने के लिये, विभिन्न अकार्बनिक अवशोषकों के साथ उच्छिष्टों को उपचारित करने का साध्यता संशोधन किया गया। सिद्धान्तः उपचार साध्य पाया गया । इन उच्छिष्टों को उपचारित करने में प्रकाश रसायन प्रक्रिया का भी अध्ययन किया गया ।

# 2

# बहुलक एवं झिल्ली विज्ञान

## झिल्ली विज्ञान एवं प्रौद्योगिकी

### विद्युत अपोहन – सम्पादन वृद्धि मे संवाही अन्तरक

विद्युत अपोहन में तनुकरण कक्ष की संवाहिता बढ़ाने के लिये संवाही अन्तरकों का उपयोग किया जाता है । प्रत्येक कक्ष में एक ऋणायन, एक धनायन विनिमित झिल्ली तथा उनके बीच एक संवाही अन्तरक होता है । संवाही अन्तरक का उपयोग ऊर्जा खर्च कम करता है तथा pH में परिवर्तन रोकता है । संवाही अन्तरक के बिना तथा साथ में, किये गये झिल्ली प्रवाह–दाब वक्र के व्यवस्थित अध्ययन ने, एक के बदले दो संवाही अन्तरकों के उपयोग की आवश्यकता दर्शायी, जिसमें धनायन झिल्ली धनायन विनिमय सामग्री के संवाही अन्तरक और वैसे ही ऋणायन झिल्ली ऋणायन विनिमय सामग्री के संवाही अन्तरक, का सामना करती है । यदि ये दोनो अंतःपरिवर्तन करते हैं तो एक की धारा दक्षता कम होती है और pH में परिवर्तन आता है । संवाही अन्तरकों का उपयोग सर्वविदित है, लेकिन इस में उनके एक साथ विशेष ढंग से प्रयुक्त करने पर कार्य किया गया है ।

संवाही अन्तरकों का उपयोग विद्युत अपोहन का क्षेत्र बढ़ाता है । विद्युत अपोहन के उपयोग से सिर्फ 500 ppm तक के पानी का विलवणन किया जाता था और यदि इससे ज्यादा ppm वाले पानीका विलवणन करना पडता, तो प्रवाह की क्षमता कम हो जाती तथा pH में परिवर्तन हो जाता था । अब इन संवाही अंतरको के उपयोग से 500 ppm से भी ज्यादा ppm वाले (50-100 ppm तक) पानी का विलवणन संभव हुआ है अर्थात कम नमकवाला उत्पादन प्राप्त किया जाता है । जैसा कि इस कार्य में बताया गया है, झिल्लियों के प्रकार के आधार पर संवाही अन्तरकों को उचित स्थिति में रखने से विद्युत अपोहन के क्षेत्र में वृद्धि हुई तथा pH परिवर्तनहीन जैसा रहा । उदाहरण के तौर पर एमीनो एसिड का विलवणन करके सिर्फ 50 ppm नमकवाला एमीनो एसिड प्राप्त किया गया ।

### सुरक्षित पेय–जल हेतु साधन / प्रौद्योगिकी का विकास

इस के अंतर्गत, प्रक्रिया, उत्पादन आदि विकसित करने की दिशा में सतत किये जा रहे प्रयत्नो के फलस्वरुप पानी के विलवणन के लिये, घरेलू विद्युतअपोहन एकम तथा 15 लीटर प्रतिघण्टा की क्षमतावाले फ्लोराईड रहित स्तंम्भ की सरंचना की गई तथा इन्हें बनाया गया, जिसका परीक्षण कार्य चल रहा है । इस उपकरण का उपयोग नमकीन जल को पीनेयोग्य पानी में परिवर्तित करने तथा उसमें से फ्लोराईड दूर करने के लिये किया जा सकता है । जिसका लोगों के स्वास्थ पर सीधा प्रभाव पड़ेगा ।

प्रतिवर्ती रसाकर्षण तकनीक पर आधारित विशेष घरेलू साधन के अतिरिक्त व्यापारिक तौर पर प्राप्त घरेलू पानी शुद्धिकरण साधन, नमक दूर नहीं करते । यह विद्युत अपोहन संयत्र, मुख्यतः प्लास्टिक सामग्री, परिशोधक के लिये सरल विद्युत परिपथ, तथा संक्षारण रहित कम दाब वाले साधारण पम्प से बनाया गया है, और इसमें कोई चलित अंश न होने से संयत्र परिचालन एकदम सरल है । घरेलू विद्युत अपोहन विलवणन पद्धति की सरंचना का उचित परीक्षण करके, आवश्यक परिवर्तन किये जा रहे हैं ।

### आयन–चयनशील रेज़िन के उपयोग द्वारा घरेलू फ्लोराइड–विहीनीकरण एकम का विकास

वर्तमान फ्लोराइड विहीनीकरण प्रौद्योगिकी में, मुख्यतः अवक्षेपण तथा अधिशोषण पद्धति के उपयोग का प्रयत्न, सीमित सफलता के साथ किया जा रहा है ।

अवक्षेपण तकनीक द्वारा उपचरित जल में जहाँ क्षारीयता ज्यादा होगी तो अधिशोषण तकनीक में एल्युमीनियम फ्लोराइड का विलेयक संकुल मिलेगा । समाप्ति तल के पुनरोत्पादन से फ्लोराइड विहीनीकरण क्षमता बहुत कम होगी । आयन चयनशील रेज़िन के उपयोग द्वारा विकसित की गई यह तकनीक इन सब कठिनाईयों से मुक्त है ।

मूल रुपेण क्लोरो–आल्कली उद्योग में, झिल्ली तकनीक द्वारा, कास्टिक सोडा बनाने के लिये ब्राईन के माध्यमिक, शुद्धिकरण के लिये विकसित किये गये रेज़िन का, यह अतिरिक्त उपयोग एल्युमिनियम रेज़िन के रुपमें फ्लोराइड विहीनीकरण के लिये किया गया । तदुपरांत यह इस तथ्य पर प्रकाश डालता है कि ऐसे रेज़िन फ्लोराइड को, पानी के साथ संकुल बनाकर, दूर कर सकते हैं ।

## ब्राइन शुद्धिकरण रेज़िन का विकास

ब्राइन शुद्धिकरण के लिये सर्वप्रथम बार ही नान–स्टाईरेनिक तथा संपूर्ण एलीफेटिक गुणधर्मवाले रेज़िन विकसित किये गये । इस के कार्य उत्पादन में परंपरागत रुपसे प्रयुक्त किये जानेवाले क्लोरोमिथाइलीकरण–पथ, जिसमें उच्च कर्कट जनन रसायनों की आवश्यकता रहती हैं, – का उपयोग आवश्यक नहीं है । एलीफेटिक होने के कारण यह जलप्रेमी है इसलिये जलीय माध्यमों में दक्षरुपेण प्रयुक्त होने में इसके काफी अवसर है । अभी उद्योगों में प्रयुक्त एमीनोडाइकार्बोक्सिलिक एसिड प्रकार के रेज़िन के बदले एमीनोमिथाइल फोस्फोनिक एसिड प्रकार के रेज़िन अल्कलाइन अर्थ के लिये ज्यादा विशिष्ट है । आल्कली उत्पादन के लिये, झिल्ली कक्ष में ब्राइन भरने से पहले, आल्काइन अर्थ मेटल आयन्स ($Ca^{++}$) को $< 20$ ppb तक दूर करने के लिये ऐसे रेज़िन का उपयोग ब्राईन के अंतिम शुद्धिकरण के लिये किया जाता है ।

''द गुजरात अल्कली एन्ड केमीकल्स लिमिटेड'' बरोडा इस रेज़िन को विकसित, अधिकतम बनाने तथा अपने परीक्षण संयत्र रनोली – बरोडा में परखने के लिये विशेष सहायता कर रहा है ।

## पोलीसल्फोन झिल्ली का प्राचलीय अध्ययन

रसायण, खाद्यान्न, तथा औषधीय उद्योगो में विविध विलगन/सांद्रण प्रक्रियाओं के लिये पोलीसल्फोन से तैयार की गई पराछनन झिल्लियों का व्यापक उपयोग होता है । सामान्य वातावरण, सरल लेकिन विश्वसनीय कम उर्जा व्यय तथा पर्यावरण मित्र बनकर कार्य करने के प्रक्रिया के लाभकारी गुणों के कारण इन झिल्लियों पर आधारित उपयोग तेजी से बढेंगे ।

सामान्यतः संघटित झिल्ली के विकास हेतु प्रयुक्त होने वाली पोलीसल्फोन आधारित झिल्ली, जल विरागी होने से नैनो–छनन में कम दाब तथा कम प्रवाह की समस्या पैदा करती है । इस के विकल्प के रुप में, छोटे पैमाने पर पोलीइथर सल्फोन (PES) से सरंध्र झिल्लियाँ तैयार करना संभव हुआ । पोलीइथर सल्फोन जलरागी, सस्ता, देशज एवं सरलता से प्राप्त है तथा इसमें पोलीसल्फोन के गुणधर्मो के समान ही उच्च उष्मा स्थिरता ($T_g = 225^0 C$) तथा उच्च रसायनिक स्थिरता के गुण पाये जाते हैं । रन्ध्रमापी द्वारा पोलीसल्फोन तथा पोलीइथर सल्फोन की सरंध्र कद/सरंध्र वितरण पर मूल अध्ययन किया गया । इस अध्ययन कार्य द्वारा रंध्र के कद, रंध्र के कद में विभिन्नता तथा रंध्र के घनत्व (विभिन्न नियंत्रित परिस्थितियों में तैयार होने पर) आदि पर जानकारी प्राप्त हुई । प्रथम चरण में छोटी आधार झिल्लियाँ बनाने के लिये काँच की प्लेट पर ढलाई का प्रयोग किया गया । बादमें इन झिल्लियों से प्राप्त शुद्ध पानी की चुंबकशीलता स्थिरांक (PWP) का मूल्यांकन तथा रंध्रकद वितरण के अभिलक्षणन का अध्ययन किया गया । प्रारंभिक प्राप्त परिणामों से पता चला कि

प्राप्त शुद्ध पानी का प्रवाह प्रसंशनीय उच्च रहा और साथ ही संघटित झिल्ली विकास के लिये सरंध्र नाप भी उचित था । पतली संघटित (TEC) झिल्ली विकसित करने के लिये पोलीइथर सल्फोन की कार्यदक्षता तथा फायदे स्थापित करने से पहले ढलाई की शर्तो के आधार पर बड़े पैमाने पर पोलीइथर सल्फोन झिल्ली विकसित करने के प्रयत्न जारी हैं ।

## जड़ी–बूटियों / पौधों के अर्क के सांद्रण के लिये सांद्रको का विकास

जड़ी बूटियों तथा पौधों के अर्क के सान्द्रण का वर्तमान चलण घूर्णक बाष्पन विधि है । इस विधि में बहुत समय लगता है तथा प्रक्रिया के उच्च तापमान के कारण इसमें कई बार जैवाण्विक असरग्रस्त होते है । जिससे पौधो के अर्क के योग्य सांद्रण में बाधा उत्पन्न होती है । झिल्ली पर आधारित सांद्रक इन सब बाधाओं को दूर करता है क्योंकि इसका परिचालन सामान्य तापमान पर होता है तथा जल सुखानेकी प्रक्रिया बहुत ही शीध्र करता है । इस तरह यह साधन असंख्य जलीय पौधो के अर्क के अध्ययन के लिये बहुत ही सुविधाजनक है ।

यह सांद्रक पोलीसल्फोन –पोलीमाईड (PS-PA) पतली संघटित फिल्म (TFC) झिल्ली पर आधारित है तथा अर्क में से सिर्फ पानी को दूर करता है। इसमें 2" x 12" (5 से.मी x 30 से.मी.) के कारट्रिज का उपयोग किया जाता है । इस साधन द्वारा 3 लीटर जलीय अर्क को दो घण्टे से भी कम समय में 75% सांद्र किया जा सकता है । हालाँकि पानी को दूर करना अंशतः पौधो / जड़ी–बुटी के अर्क की सांद्रता तथा श्यानता पर आधारित है । इसका अतिरिक्त लाभ यह है कि रोटावेपर की तरह इसमें झाग बनने से रुकता है, इसलिये झाग दूर करने की समस्या का निराकरण नहीं करना पड़ता और परिणामस्वरुप कार्यक्षमता बढ़ती है ।

यह सांद्रक वैज्ञानिक तथा औद्योगिक अनुसंधान परिषद की आंतर प्रयोगशाला द्वारा ''औषध'' पर संपन्न कार्यक्रम के लिये विशेष रुपसे विकसित किया गया । प्रतिभागी प्रयोगशालाओं के वैज्ञानिकों को इस सांद्रक का प्रदर्शन किया गया और सबने इसकी उपयोगिता को स्वीकार किया । परिषद की आंतर प्रयोगशालाओं द्वारा "नये जैवसक्रियकों तथा परंपरागत संश्लेषण की खोज, विकास तथा व्यापारीकरण" पर संपन्न सहयोगी कार्यक्रम में प्रतिभागी प्रयोगशालाओं को अबतक इस तरह के तेरह युनिट भेजे गये हैं ।

## बड़े पैमाने पर प्लान्ट के लिये 20से.मी. x 1मीटर के सर्पिल साधन का विकास

अभी विश्वमें प्रतिवर्ती रसाकर्षण संयत्र में 20 से.मी. व्यासवाला सर्पिल नमूना मानक माना जाता है । इस विकास से बड़े पैमाने तथा कम कीमत पर अपक्षारीकरण प्लान्ट बनाया जा सका जिससे पानी की कीमत भी उल्लेखनीय रुपसे कम होगी । यह उपकरण पीने योग्य पानी के उपरांत रिफाइनरी, उर्वरक, पावर प्लान्ट के उच्छिष्ट जल को उपचरित करने में भी उपयोगी होगा । इससे पानी का पुनःउपयोग सुनिश्चित होता है और बहिःस्त्रावोंकी समस्या का बहुत बड़े पैमाने पर समाधान होता है ।

पतली संघटित फिल्म (TFC) पोलीसल्फोन – पोलीमाईड झिल्लियों पर आधारित, 20 से.मी. व्यास तथा 1मीटर लंबाईवाला सर्पिल साधन विकसित किया गया है । प्रत्येक सर्पिल साधन में 39 वर्ग मीटर का झिल्ली क्षेत्र होता है । इसकी क्षमता तथा निर्धारित परीक्षण परिस्थितियों में इसकी क्षमता प्रतिदिन 20,000 लीटर की है तथा 95% का क्षार दूर करता है ।

इस के निर्माण में चैन्नई पट्रोलियम कोर्पोरेशन लिमिटेड द्वारा सहयोग प्राप्त हुआ है तथा उनके परिसर में बड़े पैमाने पर परीक्षण किया जा रहा है । उच्च प्रौद्योगिकी केन्द्र (CHT) ने भी 1-एम. एल.डी. क्षमतावाले संयत्र के लिये निधि स्वीकृत की है ।

## जन समुदाय के लिये प्रतिवर्ती रसाकर्षण अपक्षारीकरण इकाई

हमारे देशके बड़े जनसमूह को पेयजल के लिये भूमिगत पानी पर निर्भर रहना पड़ता है । कई बार ऐसे स्त्रोत नमकीन/क्षारयुक्त होने से सीधे पीने योग्य नहीं होते । ऐसे पानी से पीने योग्य पानी प्राप्त करने के लिये 100 लीटर/घण्टा की क्षमतावाले प्रतिवर्ती रसाकर्षण पद्धति पर आधारित अपक्षारीकरण प्लान्ट आकृतिबद्ध तथा तैयार करके, गुजरात के कच्छ ज़िले में लगाये गये हैं ।

यह विकसित एकम महत्तम 5,000 मि.ग्रा./लीटर टी.डी.एस. वाले जल को 500 मि.ग्रा./लीटर टी.डी.एस. वाले उच्च गुणवत्ता युक्त पीनेयोग्य पानी में परिवर्तित करने में कार्यक्षम है । इस प्रक्रिया द्वारा संपूरित जल में से जीवाणु भी पूर्ण रुपसे दूर हो जाते हैं । यह एकम एक तथा तीन फेज पावर संपूर्ति, दोनों रुपसे तैयार किया गया है । इस के परिचालन में 1.2 कि.वाट/घण्टा विद्युत खर्च होता है और यह विद्यालयों, कार्यालयों, बैंक, छोटे तथा मध्यम उद्योगों, छोटे गाँव आदि के लिये अत्यंत सुविधाजनक है ।

यह एकम एक बूस्टर पम्प, उच्च दाब वाला पम्प, 10μ फिल्टर, 5μ फिल्टर, बेग फिल्टर, झिल्ली मोडयुल, नियत्रिंत पेनल, तथा सुरक्षा बर्हिकाट से बना है । इस एकम में CSMCRI में बनी संघटित पतली फिल्म झिल्लयों के दो प्रतिरुपण (मोडयूल्स – (30से.मी. व्यास x 1मीटर) लगाये गये हैं, जो 10कि.ग्रा./से.मी.$^2$ से 15कि.ग्रा./से.मी.$^2$ दाब के परास में संपूरित पानी के आधार पर परिचालित होता है ।

गुजरात के कच्छ ज़िले में ऐसे तीन एकम में से, दो विवेकानंद अनुसंधान संस्थान में तथा एक सृजन (स्वैच्छिक संस्था) में कार्यरत है । सभी एकम संतोषप्रद कार्य कर रहे हैं । विवेकानंद अनुसंधान संस्थान तथा प्रशिक्षण संस्थान के लिये एक और एकम बनाया जा रहा है । इन एकमों का खर्च इन संस्थानों द्वारा वहन किया गया ।

## पीने के पानी से फ्लोराइड दूर करने के लिये पतली संघटित फिल्म झिल्ली का विकास

यद्यपि अन्य अभिगम अनुसार पानी से फ्लोराइड दूर करने के लिये खुली ऋणभार युक्त पतली संघटित फिल्म अतिसुक्ष्म निस्यंदन (NF) झिल्ली का उपयोग करके अध्ययन किया गया । परीक्षण किट में, शुद्ध पानी, नल का पानी, तथा सोडीयम क्लोराइड युक्त (NaF) पानी के साथ फ्लोराइड विहीनीकरण प्रयोग किये गये । परीक्षणों से ज्ञात हुआ कि पोलीपिपराज़ीन एमाइड आधारित अतिसूक्ष्म निस्यंदन झिल्लियाँ फ्लोराइड दूर करने के लिये प्रयुक्त की जा सकती है । वास्तव में ये झिल्लियाँ संपुरित जल तथा परिचालन परिस्थितियों के आधार पर 50 से 85 प्रतिशत फ्लोराइड दूर करने में सक्षम हैं । साथ ही साथ ये झिल्ली नमकीन जल (0.1 0.2%) से 30 से 35 प्रतिशत सोडीयम क्लोराईड (NaCL) भी दूर कर सकती हैं । इन झिल्लियों में 70 से 75 प्रतिशत क्षार (हार्डनेस) दूर करने की क्षमता भी पाई गई ।

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# जैव–लवणता

## समुद्री शैवाल

### समुद्री–शैवाल की खेती और मूल्यवृद्धि

**यूकोमा :** विश्व में K केराजिनन के व्यापारिक उत्पादन के लिये युकोमा एक मात्र एवं सबसे अच्छा महत्वपूर्ण स्त्रोत है । फिलिपीन्स, इन्डोनेशिया तथा अब तांजानिया में इस शैवाल की खेती बड़े पैमाने पर (विस्तृत स्तर पर) की जाती हैं । केन्द्रीय नमक व समुद्री रसायन अनुसंधान संस्थान, भावनगर ने इस शैवाल को मणार की खाड़ी में उगाने का कार्य सफलतापूर्वक किया तथा पोलीथीन की बेग और खुले समुद्र में इसकी खेती की विभिन्न प्रक्रिया विकसित की हैं । पोलीथीन बेग, बीज के रुप में शैवाल के जननद्रव्यों को सुरक्षित रखने में, विशेष अनुकूल पाई गई जबकि समुद्र में रस्सी पर की गई खेती से प्राप्त उपज में बायोमास उच्चतम पाया गया । समुद्र में तूफान के समय मछली–जाली से बनी बेग बहुत ही उपयोगी साबित हुई । इन बेगों के उपयोग से शैवाल का अलगन तथा पानी के साथ बह जाने के कारण शैवाल की कमी के प्रश्न का निराकरण करने के साथ, ये बेग, वृद्धि को नुकशान किये बगैर, निकम्में घास उगाने की प्रक्रिया भी रोकते हैं । थनाथुराई में बेग की संख्या बढ़ाकर तथा फसल का समय 90 दिन के बदले 45 दिनका करके, 9-12 टन/फसल/वर्ष उपज ली जा सकी । कृसडाई द्वीप में इससे भी उच्च उपज मिली जबकि पाल्कबाई स्थान वृद्धि के लिये कम सहायक था । इन परिणामों की अंतर्राष्ट्रीय विशेषज्ञों द्वारा दर्शित, अन्य स्थानों के विवरण के साथ तुलना संतोषजनक पाई गई । विश्वसनीय परिणामों के कारण संस्थान ''पेप्सीको होल्डींगस इन्डिया लिमिटेड'' को प्रौद्योगिकी हस्तांतरण करने में समर्थ हुआ । यह कंपनी भारत में सर्वप्रथम बार व्यापारिक स्तर पर समुद्री शैवाली की कृषि आमंत्रित कर रही है । कृषि पद्धति के विकास उपरांत पादप भ्रूण उत्पति विज्ञान सम्मिलित उत्तक संवर्धन (टीस्यु कल्चर) द्वारा जननद्रव्यों में भी सुधार किया गया । उत्तक संवर्धन द्वारा उगाई गई समुद्री शैवाल की उपज तथा शुद्ध गुणवत्ता युक्त केरागिनन की उपज संतोषप्रद रही । उत्तक संवर्धन तकनीक का, विशेष मात्रा में बीज संग्रह करने के लिये भी उपयोग किया जा सकता है । युकोमा से अर्ध परिष्कृत K-केराजिनन प्राप्त करने की प्रक्रिया के लिये पाईलोट प्लान्ट तैयार किया गया है । इसमें पानी का उपयोग कम करके प्रक्रिया में आवश्यक आल्कली का पुनः उपयोग करने की सरल प्रक्रिया विकसित की गई है । परिष्कृत K-केराजिनन की प्रक्रिया में भी सुधार किया गया है । अब अल्कोहल का उपयोग करने के नवीन अभिगम पर संशोधन हो रहा है । युकोमा का परंपरागत उपयोग – K केराजिनन के स्त्रोत के उपरांत, इस शैवाल की समुदी जल से विशेष मात्रामें पोटाश्यिम आयन संग्रह करने की क्षमता का भी पूर्ण दोहन करके ''बायोपोटाश'' विकसित किया गया ।

**जेलीडीयेला एकेरोसा :** सर्वोत्कृष्ट वृद्धि, अगार की उपज तथा जेलक्षमता का निर्धारण करने के लिये कोरल स्टोन पर जेलीडीयेला एकेरोसा के विभिन्न नस्लों की खेती की गई । बायोमास उपज के आंकड़े दर्शाते हैं कि CSMCRI फार्म, कीलाक्करई, तथा शेखुकराई से एकत्रित की गई शैवाल में, दूसरे स्थान से एकत्रित की गई शैवाल की तुलनामें उच्चतम बायोमास उपज प्राप्त हुई । CSMCRI फार्म से एकत्रित की गई शैवाल में अगार की उपज तथा उत्तम जेल क्षमता उसकी संपूर्ण श्रेष्ठता की पुष्टि करती है । इसलिए इस जननद्रव्य को जेलीडीयेला की खेती के लिये बीज के रुप में संग्रहित किया गया है । बायोमास की महत्तम उपज के लिये विभिन्न बीजारोपण घनत्व (200, 300, 400, 500 तथा 600 ग्रा/मी $^2$) का अध्ययन किया गया । बीजारोपण घनत्व परीक्षण के दौरान देखा गया कि प्रथम फसल में 400 ग्रा/मी $^2$ से औसतन 2.31 कि.ग्रा/मी $^2$ उपज तथा

दूसरी फसल में 1.15 कि.ग्रा/मी$^2$ उपज मिली । विभिन्न कृत्रिम आधारों पर भी अध्ययन किया गया । उपर्युक्त अध्ययनों के आधार पर खोखले (होलो) सिलिंडराकार सिमेन्ट ब्लोक तैयार किये गये और ऐसे 6000 ब्लोकों का समुद्र में अनुकूलन करने के बाद विशिष्ट जनन द्रव्यों का बीजारोपण किया गया । अब संस्थान के फार्म में उगाये गये जेलीडीयेला एकेरोसा से उच्च गुणधर्मवाले, जैवाणुविक अगार स्वदेशी रुपसे उत्पादित करना संभव हुआ है । जैवाणुविक उत्पाद्य अगार का चिकित्सालय में, ओक्सोट्रोपिक अध्ययनों, जीवाणु तथा खमीर बनाने के अध्ययन, जैवाणुविक आनुवंशिक उपयोग तथा स्तनीय और पादप उत्तक संवर्धन में उपयोग किया जाता है । भारत में जैवाणुविक स्तर के अगार की आवश्यकता की पूर्ति ज्यादातर बहुत महंगे दाम पर अमरीका से डीफ्टो–बेक्टो अगार जैसे उत्पादनों की आयात द्वारा की जाती है । इस प्रक्रिया में समुद्री शैवाल के उचित पूर्वोपचार के बाद दाब द्वारा अगार का अर्क निकाला जाता है । प्राप्त प्रवाही अगार को निस्यंदन द्वारा शुद्ध करने के पश्चात उत्पाद्य को हिमद्रवण पद्धति द्वारा परिष्कृत किया जाता है । तत्पश्चात अगार के टुकड़े को पीसकर पावडर के रुपमें, अंतर्राष्ट्रीय स्तर के अगार की गुणवता के समान गुणवत्तावाले, जैवाणुविक अगार की उपज प्राप्त की जाती है । यह प्रक्रिया 1.5 कि.ग्रा/सूखी शैवाल/बैच के स्तर पर विकसित की गई है । इस अगार की उपज में 25% वृद्धि है । (सूखी अगार पर आधारित) मानक परिमाणों के अनुसार इस उत्पाद्य की जेलक्षमता 600ग्रा/सेमी$^2$ तक पाई गई है । (1.5 प्रतिशत जेल ; 20$^0$C) इस संशोधन कार्य के लिये बायोटेकनोलोजी तथा उद्योग विभाग ने आंशिक रुपसे वित्तीय सहायता प्रदान की है ।

## सल्फेटीकृत पोलीसेकेराइड्स

सल्फेटीकृत पोलीसेकेराइडस की परीक्षण पद्धति विकसित की गई । अर्क को आयन विनिमय तथा जेल कॉलम क्रोमेटोग्राफी द्वारा शुद्ध किया गया । शुद्ध सल्फटीकृत पोलीसेकेराईड के आल्डीटोल एसीटेट तैयार किये गये और बाद में मौजूद कार्बोहाइड्रेट एकलक (मोनोमोस) का जीसी–एमएस विश्लेषण द्वारा पहचान करके परिमाण निर्धारित किया गया । कैडियम द्धारकेन्स जाति की हरित शैवाल, जिसमें परीक्षणों द्वारा पहले लहूस्कंद शोधक क्षमता पाई गई थी – इस पर आगे संशोधन से ज्ञात हुआ है कि अंकुरण समय के दौरान पादप की जलीय अर्क क्षमता महत्तम होती है ।

## समुद्री शैवाल से द्रव उर्वरक (LSF)

CSMCRI द्वारा निर्मित समुद्री शैवाल द्रव उर्वरक की अन्य विभिन्न ब्रांड के रसायनिक संमिश्रण के द्रव उर्वरकों (NPK तथा कुछ ट्रेस एलीमेन्टस) के साथ तुलना की गई । विवरणों से ज्ञात हुआ कि CSMCRI द्वारा निर्मित द्रव उर्वरक, अन्य उर्वरकों के साथ तुलनीय हैं । महत्तम TDS के गुणधर्मवाले उत्तम द्रव उर्वरक क्षमता चयन करने के उद्देश्य से विभिन्न सरगासम शैवाल की प्रवाही उर्वरक क्षमता का विश्लेषण किया गया । सरगासम स्वार्तज़ी में उच्चतम TDS(12.9) पाया गया । सरगासम को अल्वा के साथ 75:25 के अनुपात में मिलाया गया । फलतः N:P:K का प्रारंभिक अनुपात 2.5 : 2.5 : 0.085 से बढ़कर 3.75 : 3.10 : 0.12 हो गया ।

बायोविलेज, मोचा में प्याज पर इसके क्षेत्र–परीक्षण किये गये जिससे द्रव शैवाल उर्वरक के 10 प्रतिशत सांद्रण द्वारा, प्याज में 16 प्रतिशत की वृद्धि पाई गई ।

भावनगर के लाखणका गाँव में प्याज की फसल पर विभिन्न सांद्रतावाले द्रव शैवाल उर्वरक के छिड़काव का उपयोग किये जाने पर, प्याज में 17 से 29 प्रतिशत की वृद्धि पाई गई । जोजोबा रोपण से पहले, जमीन में द्रव शैवाल उर्वरक के उपयोग करने पर, जोजोबा की ऊँचाई में तथा शाखाओं मे लगभग 50 प्रतिशत की वृद्धि पाई गई । गेहूँ तथा मूंगफली पर भी प्रयोग किये गये जिसमें

सकारात्मक प्रभाव देखने को मिला ।

## बायोपोटाश

पोटाश उत्पादन के स्त्रोत के रुपमें युकोमा के उपयोग पर विस्तृत अध्ययन किया गया । युकोमा तथा युकोमा राख का बैंगन तथा गेहूँ पर उपयोग करने पर, क्रमशः 33 तथा 42 प्रतिशत की उच्चतम उपज प्राप्त हुई । 75 दिन के विग्ना रेडीएटा पौधे के पर्ण पर युकोमा अर्क का उपयोग करके पौधे की वृद्धि तथा बीज–उपज पर उसकी असर का अध्ययन किया गया । 10 प्रतिशत युकोमा अर्क से उपचरित पौधे से लगभग 50 प्रतिशत विशेष उपज प्राप्त हुई । इससे कम अथवा ज्यादा प्रतिशत में युकोमा अर्क का उपयोग करने से, कम प्रभाव देखा गया ।

## रोगाणुविक प्रक्रिया

प्रोटिएज़ उत्पादन करनेवाले समुद्री जीवाणुओं को अलग किया गया । अवक्षेपित एमोनियम सल्फेट, कॉलम क्रोमटोग्राफी तथा जेल निस्यंदन द्वारा बाह्य–कोशिका प्रोटिएज को अत्यंत शुद्ध रुपमें प्राप्त किया गया । अलग किए गये प्रोटिएज में K-कैराजिनन पर स्थिरीकरण द्वारा सुधार किया जा सका । स्थिर एन्जाईम (प्रकिण्व) को 20 दिन तक $< 15^0$ सेन्टीग्रेड में रखे जाने पर भी उनकी सतत क्रियात्मकता बनी रही और यह भी देखा गया कि स्थिर एन्जाईम को केसीन अवक्रमण (डीग्रेडेशन) के प्रति क्रियाशीलता में बिना विशेष हानि के 6 से 8 बार उपयोग में लिया जा सका ।

## निर्गमों का जीव विज्ञानीय उपचार

रंग उद्योग के निर्गम से जीवाणु तथा फंफूद संवर्धनो को अलग किया गया और निर्गम को उपचरित करने के लिये दोनों का स्वतंत्ररुप से उपयोग किया गया । जीवाणु संवर्धन के मामले में 15 से 16 दिन में COD में 90 प्रतिशत कटौती पाई गई जबकि फंफूद संवर्धनों ने COD मे विशेष कमी नहीं दर्शायी । जीवाणु संवर्धन तथा फंफूद संवर्धन का उपयोग करके निर्गम के रंग विहीनीकरण पर अध्ययन किया गया । जिससे ज्ञात हुआ कि फंफूद संवर्धन ने निर्गम के रंग को प्रभावकारी रुपसे 94 प्रतिशत दूर किया ।

फफूंदनाशी निर्माता उद्योगों के निर्गम से तीन विभिन्न जीवाणु संवर्धक अलग किये गये और उनका स्वतंत्र रुपसे एवं क्वक शैवाल सहजीविता के रुप में उपयोग किया गया । क्वक का शैवाल सहजीविता के रुपमें उपयोग करने पर COD में 88 प्रतिशत तक उल्लेखनीय कटौती पाई गई ।

एक रंग उद्योग के निर्गम के वर्णसूचक (क्रोमोफोटीक) ग्रुप का नाश करने तथा बाद में रंग दूर करने के लिये इसे विद्युत रसायनिक रुपसे उपचरित किया गया । तत्पश्चात निर्गम से जीवाणु संवर्धन की उपस्थिति में रोगाणु तथा COD में 16 दिन के अन्दर कमी पाई गई ।

विभिन्न अति क्षारवाले निर्गमो को उपचरित करने के लिये सायनोबेक्टेरीयल क्वक शैवाल का जाली के जैव निस्यंदक के रुप में उपयोग किया गया । जिससे 60-80 प्रतिशत रंगविहीनता पाई गई ।

## जैवरंजक

स्पीरुलीना समुद्री शैवाल से सी–फाईकोसायनीन नामक उच्च प्रतिदीप्त रंजक के उत्पादन के लिये एक प्रक्रिया विकसित की गई । उसकी कृषि, कटाई, निष्कर्षण तथा शुद्धिकरण के लिये निर्धारित की गई महत्वपूर्ण, नवीनतम, प्रक्रियाओं द्वारा सूखे वजन के आधार पर 10 प्रतिशत उच्च C-PC की उपज प्राप्त हुई ।

## पादपलवणता

### लवणोद्भिद में नमक सह्यता क्रियाविधि

सेलेकोर्निया ब्रेचीएटा की नमक सह्यता क्रियाविधि का अध्ययन किया गया । लवणोद्भिद की नमक सह्यता क्रियाविधि में, आयनों का विशिष्ट उत्तक उपखंड बनाना, प्रकिण्वीय (एन्जाइमेटीक) क्रियाओं में परिवर्तन, परिवर्धिन सरसता आदि महत्वपूर्ण पहलू साबित हुए हैं । कोशिका/कोष संवर्धन तथा पूरे पौधे की नमक सह्यता की तुलना से ज्ञात हुआ कि नमक सह्यता में, उसकी रचना संबंधी जटिलता तथा क्रियात्मक संपूर्णता मुख्य आधार हैं । सेलिकोर्निया पर्सिका के सेम (SEM) तथा इडेक्स EDAX का उपयोग करके उसकी सह्यता की मर्यादा तथा सोडियम ब्रोमाईड और सोडियम क्लोराईड में वितरण पद्धति का अध्ययन किया गया । सोडियम क्लोराईड NaCL तथा NaBr, के समाणुक (इक्वीमोलार) सांद्रण पर ब्रोमाईड तथा क्लोराईड का संचय क्रमशः 60 और 63 प्रतिशत था ।

यदि ये पौधे विषैले आयन उपखंड़ो से होनेवाली हानि को रोककर उसकी सरसता वृद्धि करते हैं तो इस क्रियाविधि की समझ का अत्याधिक प्रायोगिक महत्व होगा । अनुसंधान से प्राप्त परिणामों से हमारे ज्ञान में वृद्धि होगी कि कैसे ये पौधे प्रोटीन वहन क्रिया को उत्तेजित करते है जो नमक संवेदनशील चयापचय क्रियाविधि में से $Na^+$ अलग करता है तथा उत्तकों की सरसता में वृद्धि एवं निर्जलीकरण से बचाता है । प्राप्त परिणामों से नवल आण्विक जैव विज्ञानीय अभिगम द्वारा फसल की लवणता प्रतिक्रिया में सुधार किया जायेगा ।

### तटीय खारी मिट्टी में सेलिकोर्निया ब्रेचिएटा की खेती

सेलिकोर्निया ब्रेचिएटा, लिनोलिक एसिड के रुपमें समृद्ध खाद्य तेल (>75%) का स्त्रोत है । अत्यंत खारी मिट्टी पर, यथावत परिस्थिति में नमकीन जल की सिंचाई द्वारा, सौराष्ट्र के घोघा तथा तट्टीय क्षेत्रो पर से एकत्रित किये गये जननद्रव्यों का उपयोग करके सेलिकोर्निया ब्रेचिएटा की खेती की गई । इन में से कुछ उच्च उपज क्षमतावाले पौधे चयन किये गये । इनकी उपजक्षमता तथा बायोमास उत्पादन का मूल्यांकन करने के लिये उन्हें अलग क्षेत्रो में उगाया गया । प्राकृतिक रुप से उगे पौधो की तुलना में इन पौधों की उपज (प्रत्येक पौधा, क्षेत्र) ज्यादा पाई गई । परिणाम स्वरुप प्रतिपौधा बीज उत्पादन में उल्लेखनीय वृद्धि हुई । परीक्षणों द्वारा आकारिकी विभिन्नता अर्थात, रंग, प्रतिपौधा, बाली तथा खंड (स्पीक्स तथा सेगमेन्टस) की संख्या तथा विस्तरण प्रवृति को पहचाना गया । तटीय उसर जमीन को सुधारने की विशेष क्षमता को ध्यान में रखते हुए गुजरात स्टेट फर्टिलाइज़र कंपनी (GSFC) सायन्स फाउन्डेशन – बरोड़ा ने इस योजना को प्रायोजित किया है ।

### सेलिकोनिर्या से खाद्यतेल

उपरोक्त अनुसार सेलिकोर्निया ब्रेचिएटा खाद्यतेल का उपयोगी स्त्रोत है जो लिनोलिक एसीड से समृद्ध है । सेलिकोर्निया ब्रेचिएटा के बीज कद में छोटे है और पारंपारिक निष्काषन पद्धति बहुत कठिन है । तेल का विलायक निस्सारण (सोल्वन्ट – एक्सट्रेशन) संभवित है लेकिन पत्ते में तेल का विलायक निस्सारण असंभव है। अतिक्रान्तिक तरल निष्कासन प्रौद्योगिकी (SFE) (सौजन्य – आई.आई.टी, पवई) का उपयोग करके 1.125 कि.ग्रा सेलिकोर्निया बीज पर 300 बार दाब पर 2 धण्टे तक प्रक्रिया की गई और >85 प्रतिशत से भी ज्यादा पारदर्शक तेल प्राप्त किया गया । इसके प्रभाजन पर विशेष कार्य किया जा रहा है ।

## वनस्पतिजन्य नमक

अपने उत्तको में नमक संग्रह करनेकी प्रवृति रखने वाले कुछ लवणरागी पौधों से पौष्टिकता से समृद्ध नमक बनाने का एक नया अभिगम विकसित हुआ था, इसे योग्य मूर्त रुप देने के लिये प्रक्रिया विकसित की गई है । सेलिकोनिर्या एक एसा ही पौधा है । इस पौधे से एकदम स्वच्छ, सफेद, स्फटीकमय तथा मुक्त स्त्रावी खाद्य नमक प्राप्त किया जा सका । जिसमें 5-15 प्रतिशत पोटाशियम क्लोराईड तथा आर्यन जैसे कुछ महत्वपूर्ण अणुपोषक (माइक्रो न्युट्रीन्टस) निहित है ।

## जेट्रोफा की खेती

जैट्रोफा, विस्तृत रुपसे समग्र भारत में पाईजानेवाली बारहमासी झाड़ी है, जो गुजरात राजस्थान, आंध्र प्रदेश, जैसे शुष्क तथा अर्द्ध शुष्क, प्रदेशो में पाई जाती है । इस के बीज, ओलेईक एसीड (60-70%) से समृद्ध अखाद्य तेल के स्त्रोत हैं । हाल में अपक्षारी जमीन के इस पौधे में जैव–ईधन के स्त्रोत की संभवितता देखी गई है ।

## जेट्रोफा कर्कश के विषहीन आनुवंशिक रुप (जीनोटाईप)

जेट्रोफा के स्वदेशी पौधो से प्राप्त बीज फोरबोल एस्टर के कारण विषैले होते हैं । निम्न मात्रा में फोरबोल एस्टर वाले बीज से विषहीन प्रजाति उगाने के प्रयत्नो का अध्ययन किया गया ।

## केन्द्रीय नमक व समुद्री रसायन अनुसंधान संस्थान, के जांजमेर फिल्ड स्टेशन में जोजोबा खेती का उल्लेखनीय निष्पादन

केन्द्रीय नमक व समुद्री रसायन अनुसंधान संस्थान, भावनगर के प्रायोगिक कृषि क्षेत्र जांजमेर में जोजोबा के प्रजनन सघनता बनाये रखने के लिये अध्ययन किये गये ।

चुनिंदे जननद्रव्यो के विस्तरण के लिये सामूहिक प्रवर्धन अर्थात उत्तक संवर्धन तथा शाखा कटाई आवश्यक था । इसका एक अतिरिक्त लाभ यह है कि बीजांकुर, ज्ञात लिंग और फर्म की आयोजित रुपरेखा अनुसार होगा । प्रजनन दर बढ़ाने के उद्देश्य से, सूक्ष्म प्रजजन के लिये पहले प्रयुक्त किये जा रहे आधार माध्यम में, अब परिवर्तन किया गया है । जड़ प्रेरित ऑक्सिजन मिश्रण की संरचना में भी परिवर्तन किया गया । इस आयोजन बद्ध खेती की तकनीक द्वारा जोजोबा के उत्तम किस्म के ज्ञात लिंग वाले तथा उच्च गुणवत्ता वाले बीजांकुर शीध्र दर पर प्राप्त होने में तथा इच्छित नर–मादा अनुपात बनाये रखने में सहायता मिली । संस्थान ने जोजोबा के ज्ञात लिंग–वाले चुनिंदे पौधो के क्लोन, प्रयोगशाला में नियंत्रित वातावरण की प्रजनन पद्धति द्वारा तैयार किये तथा AJORP फार्म (घंद – जयपुर) में उगाये, जो इजरायेल के क्लोन के समकक्ष ही पाये गये तथा इन पौधो में तीसरे साल के बाद फल भी लगने लगे हैं । इससे ज्ञात होता है कि संस्थान द्वारा गृहपालित, चयनित जोजोबा के पौधों को भारतीय वातावरण विशेष अनुकूल है ।

## पौधे से अपारंपरिक कार्बनिक अणुओं का विलगन

सी.एस.आई.आर आंतर प्रयोगशाला / संस्थानो द्वारा पादप स्त्रोत से जैव सक्रियक पर संपन्न कार्यक्रम अंतर्गत कई अपारंपरिक पौधों की जातियाँ जो अबतक अनुपयोगी रही लेकिन किनारे की बंजर जमीन के लिये अत्यंत योग्य हैं, उनके औषधीय उपयोग की संभवितता पर अनुसंधान किया जा रहा है । CSMCRI द्वारा तैयार किये गये चुनिंदे पौधों का प्रयोगशालामें नियंत्रित वातावरण में (इन विट्रो) तथा बाहरी क्षेत्र के प्राकृतिक वातावरण (इन वीवो) में अनुकूल निर्धारित गुणों की पुष्टि की गई । इन अनुसंधानो की अग्रता के आधार पर काइलेरिया तपेदिक तथा मलेरिया के लिये अनुसंधान वर्ग बनाये गये ।

## समुद्री पर्यावरण

### शैवाल की जैव विविधता

भारतीय समुद्री शैवाल की संशोधित सूची संकलित की गई है । भारतीय समुद्रीतट पर कुल 844 जातियाँ बताई गई हैं, जिनमें 434 रहेड़ोफाईटा की, 216 क्लोरोफाईटा की, 191 जातियाँ फिओफाइटा और अन्य 3 जातियाँ जैन्थोफाइटा की हैं । चैकलिस्ट में प्रत्येक जाति के शैवाल की प्रजातियाँ, प्रकार आदि, भारतीय समुद्रतट के विभिन्न स्थानों पर इनकी प्राप्यता, प्रत्येक जाति के नमूने की विस्तृत जानकारी, विभिन्न पहलूओं जैसे जैविकता, प्रकार, कृषि, रसायण शास्त्र, तथा उनके उपयोग पर प्रकाशित संशोधन लेखों के संदर्भ समाविष्ट हैं ।

### समुद्र तटीय अनुश्रवण तथा पुर्वानुमान पद्धति (COMPAS)

संस्थान द्वारा समुद्र तटीय अनुश्रवण तथा पूर्वानुमान पद्धति अंतर्गत गुजरात के समुद्री तट का अनुश्रवण कार्य किया जा रहा हैं । प्रायः सामान्य परास में सभी स्थानों पर घुले ओक्सीजन, बीओडी तथा पी.एच में भिन्नता पाई गई । फिर भी कुछ जगहों पर स्थानिक प्रतिबल अवस्था पाई गई । कंडला में उच्च लवणता देखी गई जबकि ओखा में उच्च मात्रा में घुला ओक्सीजन मिला । पोशित्रा में क्लोरोक्लिव में उच्च मात्रा तथा एमोनिया के सांद्रण में कमी पाई गई । द्वारका में बीओडी तथा फाइटोप्लांकटोन की आनुवंशिक व्युत्पति उच्च मात्रा में पाई गई । पोरबंदर में बहिःस्त्रावों के निष्काषन के कारण $NO_3$, $NO_2$, $NH_4$, TN तथा TP उच्च मात्रा में पाये गये इसमें फाइटोप्लांक्टोन की गणना भी अधिक पाई गई । अलंग में सभी प्राचलनों में उच्च प्रतिबल अवस्था पाई गई ।

### भारतीय समुद्री जल में इम्पोसेक्स निरीक्षण

प्रतिदूषक (एन्टी फाऊलींग) समुद्री रंगो में निहित ट्राईब्युटाइल टीन जैसे रसायण इम्पोसेक्स – लिंग परिवर्तन समस्या का मुख्य कारण है । इम्पोसेक्स, मादा में नर लिंग का विकास होता है, जिससे अंडे देने में रुकावट, अप्रजननता तथा अन्ततः मृत्यु हो जाती है । सौराष्ट्र के समुद्र तट पर उपलब्ध थायस ब्युफो तथा ओसेनब्रा बोम्बायना जैसी नियोगेस्ट्रोपोड़ की विविध प्रजातियों पर संस्थान द्वारा किये जा रहें संशोधन के दौरान सर्वप्रथम बार ही यह घटना देखी गई । प्रत्येक प्रजाति की कुल आबादी में से थायस ब्युफो तथा ओसेनब्रा बोम्बायना में 9-10 प्रतिशत लिंग परिवर्तन पाया गया । ट्राईब्युटाइल ही लिंग परिवर्तन का मुख्य कारण है यह परखने तथा स्थापित करने के लिये आगे अनुसंधान जारी है ।

### मैंग्रुव पर बिटर्न का असर

एवीसेनिया मरीना के छोटे पौधो पर $28.5^0$ Be बिटर्न के प्रभाव का अध्ययन किया गया । समुद्री जल में 5 प्रतिशत सांद्रित बिटर्न मिलाने पर इन पौधों की वृद्धि, पत्तों की संख्या में वृद्धि, तथा पौधो के सूखे वजन में वृद्धि महत्तम पाई गई । इससे बिटर्न में पोटाश का उच्च सांद्रण मिला । यद्यपि ब्राईन और बिटर्न के 50 प्रतिशत सांद्रण से इन की वृद्धि में अवरोध हुआ जबकि 10 दिन तक के सतत परीक्षण में देखा गया कि ब्राईन और बिटर्न का 100 प्रतिशत सांद्रण पौधे के लिये घातक सिद्ध हुआ । परिणामों से ज्ञात होता है कि समुद्री पर्यावरण में ब्राईन और बिटर्न का निष्कासन अगर सही अनुपात में किया जाता है तो यह निष्कासन मैंग्रुव बीजांकुर की वृद्धि में उपयोगी होता है ।

## पर्यावरण परीक्षण

संस्थान में गुजरात की प्रतिष्ठित कंपनियो के पर्यावरणीय परीक्षण के उपरांत टाटा केमिकल्स लिमिटेड – मीठापुर, इन्डियन रेयोन इन्डस्ट्रीज लिमिटेड – वेरावल, नेशनल थर्मल पावर स्टेशन – जानोर, इन्डो गल्फ कोर्पोरेशन लिमिटेड – दहेज, गुजरात अम्बुजा सिमेन्ट लिमिटेड – कोडीनार, नर्मदा सिमेन्ट कंपनी – जाफराबाद, तथा जी.ई.बी थर्मल पावर स्टेशन – उकाई डेम, का पर्यावरणीय परीक्षण का कार्य सतत हो रहा है । इस परीक्षण का मुख्य उद्देश्य, उद्योगों के उच्छिष्टों को कम करना, कच्चे माल तथा ऊर्जा का महत्तम उपयोग करना तथा प्रदूषण रोकने के लिये उचित परामर्श देना है ।

CSMCRI

Biennial Report: 2000-2002

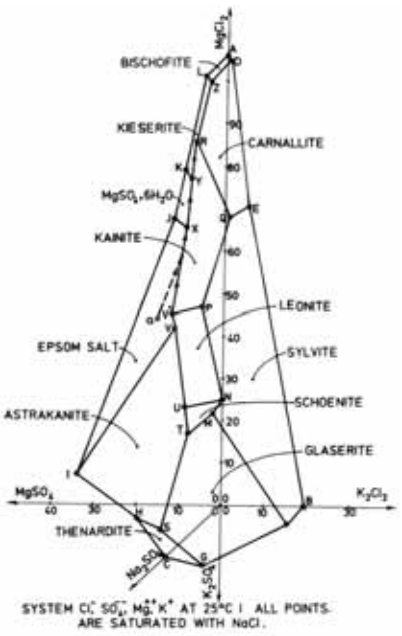
1

# INORGANIC CHEMICALS

# SALT & MARINE CHEMICALS

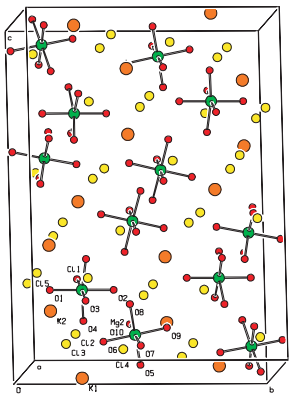
**Integrated recovery of marine chemicals along with salt quality upgradation.** India imports her entire requirement (ca. 3 million tons) of potash and there is a necessity to develop a practical process for recovery of potash from sea and sub-soil brine available in our country. This is all the more desirable since salt works in India produce 14 million tons of salt and discharge the by-product bittern into the sea, which is a source of potash, bromine and magnesia chemicals. There is also an unlimited source of natural bittern in the Greater Rann of Kutch that can be exploited for potash independent of salt production. KCl can be produced economically from carnallite double salt ($KCl.MgCl_2.6H_2O$) that is obtained from evaporation of brines that are low in sulphate (see the phase diagram below), e.g., Dead Sea brine. However, to produce carnallite with minimum NaCl contamination such that KCl of desired purity can be obtained directly upon decomposition of the double salt is a formidable challenge. Bitterns obtained from indigenous sea and sub-soil brines invariably yield the kainite-type double salt ($KCl.MgSO_4.3H_2O$) because of higher sulphate ion concentration of the brine. Processing of kainite to recover the commonly accepted forms of potash, namely KCl (MOP) and $K_2SO_4$ (SOP), is more complex and presumably the reason why no technology for potash recovery in India has been commercialized till date. The Institute has made important strides during the last two years towards development of viable technologies for KCl and $K_2SO_4$ recovery in the Indian context.

The first approach relied on identification of a practical method of desulphatation of bittern. Bittern from sub-soil brine is preferred for this purpose since its sulphate content is roughly half that of bittern obtained from sea brine. Since removal of sulphate is best accomplished with $CaCl_2$, emphasis was placed on its production through an inexpensive route. The first approach conceived was production of $CaCl_2$ from limestone and HCl, and a process has been developed to produce $CaSO_4$, carnallite and $MgCl_2$ (as end liquor containing 440 g/L $MgCl_2$). Since HCl can be obtained as by-product of refractory grade MgO manufacture from $MgCl_2.6H_2O$, production of MgO by such a calcination process has been demonstrated on 2 kg/h scale and efforts are currently underway to trap and recover HCl (PCT patent Application No. PCT/IN01/00185 dated 22 October, 2001).

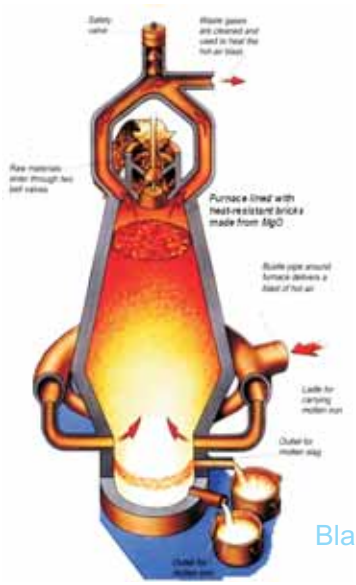



The Institute continued its search for inexpensive sources of $CaCl_2$ and recognized

that Distiller waste, which is the liquid effluent generated in the Solvay process of soda ash manufacture, holds promise. Recovery of potash and other marine chemicals through desulphatation of bittern with Distiller waste would be of interest to leading producers of salt and soda ash such as Nirma, Saurashtra Chemicals, Gujarat Heavy Chemicals Limited and Tata Chemicals who are



Single Crystal Structure of Carnallite




Blast Furnace

MgO brick

presently discharging this waste as well as the bittern into the sea. The Institute is working closely with several of these industries towards this objective, with support from Department of Ocean Development, GOI.

The Institute has utilized the concept of carnallite production through desulphatation to develop a process for low sodium salt (a mixture of NaCl and KCl) on 100 kg scale and is working actively with an industry to commercialise the process (Patent Application No. PCT/IN02/ 00018 dated 31-1-2002). The Institute has also successfully developed for the first time a process for producing carnallite in the field with <1% NaCl impurity. As a result, it is now possible to produce KCl with > 98% purity through a cold process (patent application in preparation). A second approach based on processing of 32° Be' desulphated bittern in a plant to produce KCl, low sodium salt, $MgCl_2$ liquor and pure water has also been experimented with at the laboratory scale.

A key innovation that has attracted the attention of numerous industries is the concept of desulphatation of brine for production of high purity industrial grade common salt (PCT patent Application No. PCT/IN01/00185 dated 22 October, 2001). Sulphate impurity in brine leads to build up of magnesium and calcium impurity (in the form of sulphate salt) in the

common salt and is, in that sense, the prime culprit. Soda ash and caustic soda industries devote much effort to clean up salt and any savings on this count would be to their advantage. Industrial salt of higher quality would also raise the income level of agarias since such salt would be more sought after. As can be seen from Table 1, heap washed salt produced from desulphatated sub-soil brine (column C) is superior to those obtained from sea and sub-soil brines through the conventional process (columns A, B respectively) of solar salt production being followed presently. Mechanical washing of the salt can further improve its quality and it is possible to reach specifications matching those in column D, which would be attractive even for export. The most interesting aspects of this innovation are that: (i) adoption of desulphatation methodology makes variations in the initial composition of brine irrelevant and high quality salt as indicated in Table 1 can be produced even from sub-soil brine, (ii) the yield of salt increases by ca. 15% when desulphatation is carried out with Distiller waste (the NaCl present along with $CaCl_2$ in Distiller waste contributes to salt yield while the overall increase in chloride concentration of brine throws out more NaCl due to the common ion effect), and (iii) heavy metal impurities in salt are also observed to be noticeably less as evident from ICP measurements. Although salt quality upgradation through desulphatation was conceived to make integrated marine chemicals recovery more attractive, the technology has become important in its own right and numerous companies have expressed interest in the process. This method of salt production was adopted on 100 ton scale in the Experimental Salt Farm during the last salt season.

*[A]Heap washed sea salt through traditional process; [B] Heap washed salt from sub-soil brine through traditional process; [C]Heap washed salt from sub-soil brine after desulphatation; [D] Target specification of salt to be produced after mechanical washing.*

**Table 1**

| Constituents (% w/v) | A | B | C | D |
|---|---|---|---|---|
| Ca | 0.20-0.25 | 0.30-0.40 | 0.10% | 0.04% |
| Mg | 0.04-0.07 | 0.10-0.12 | 0.05% | 0.02% |
| $SO_4$ | 0.50-0.60 | 0.80-1.00 | 0.15% | 0.11% |

## Membrane-based purification of brine

The Institute is exploring methods of eliminating impurities from seawater with a view to producing brine that may be fit for use directly by industries.

Such an approach, if successful, would eliminate the need for crystallization of salt and its redissolution to produce brine. This approach would also be useful in promoting the use of seawater for washing of salt heaps and for dissolution of salt for preparation of concentrated brine. One approach of particular interest is the use of suitable membranes that can reject divalent ions from seawater. It can be seen from Table 2 that the concentrations of $Mg^{2+}$ and $Ca^{2+}$ in seawater can be reduced by ca. 90% and 79%, respectively, through membrane processing.

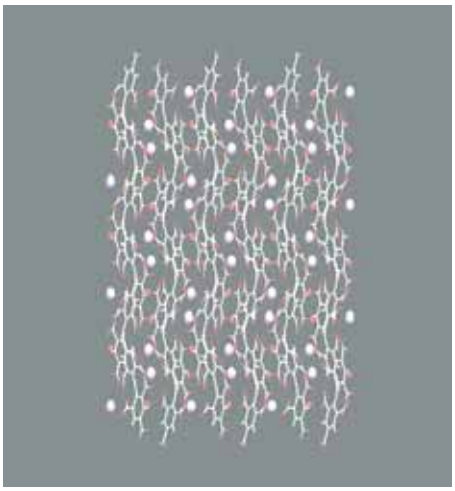
**Production of $K_2SO_4$ from Kainite-containing mixed salt:** Although ease of recovery of KCl via carnallite has been emphasized above, and its viability demonstrated in the context of integrated marine chemicals recovery including salt quality upgradation, no more than 2-3 lakh tons of KCl can be produced through this approach (~1200 tons of KCl can be produced from the bittern obtained as by-product from 1 lakh tons of salt) whereas the requirement is much larger. On the other hand, even though vast quantities of natural bittern are available in the Greater Rann of Kutch, its desulphatation on standalone basis would not be a practical proposition, although there may be some gains through integration with bromine production. More importantly, as per the opinion of agricultural experts, the sulphate in the bittern should ideally be utilized to produce SOP which is recognized as a superior fertilizer to MOP but whose consumption is limited because of its ca. twofold higher cost. With this reasoning in mind, it has been possible to produce $K_2SO_4$ of ca. 94% purity from kainite-containing mixed salt and externally added MOP. The salient features of the technology are that: (i) $K_2SO_4$ is produced through a simple cold process, (ii) apart from MOP, no other chemicals are required for treating the kainite-containing mixed salt, and (iii) ~1.5 kg of $K_2SO_4$ can be produced per kg of externally added MOP. This approach has the potential to reduce import of MOP by 35% while simultaneously offering the Indian farmer a superior fertilizer at a lower cost than the international price of SOP.

Table 2 Membrane-based Seawater purification

| Ion | Before | After | % Reduction |
|---|---|---|---|
| $Ca^{2+}$ | 0.044% | 0.009% | 79.04% |
| $Mg^{2+}$ | 0.120% | 0.011% | 90.53% |

**Ligand design for selective $K^+$ extraction from brine:** In addition to the conventional approach of marine chemicals recovery through fractional crystallization, the Institute has been exploring the possibility of developing suitable extractants for selective recovery of $K^+$ from brine/bittern. We have utilized the original concept of potash recovery from seawater with

dipicrylamine proposed by Norsk Hydro to extract $K^+$ selectively from bittern. Dipicrylamine was first treated with lime and added in stoichiometric quantity into bittern whereupon a red precipitate was obtained instantaneously. This precipitate was treated with nitric acid whereupon pure potassium nitrate was recovered and the dipicrylamine could be recycled.



*Single Crystal Structure of the potassium salt of Dipicrylamine $[K^+(dipic)^-.H_2O]$. The purple spheres depict $K^+$.*

**Development of a biological process for reducing calcium ion impurity in brine:** As indicated above, the value of salt for industrial application is strongly related to the level of calcium impurity. An innovative technology for the removal of $Ca^{2+}$ impurity from brine employing marine cyanobacteria was developed. The cultures showed good adaptability to brine compositions varying from 9° Be' to 29° Be' sea/ sub soil brine. The 42 hours old cyanobacterial cultures showed excellent ability to accumulate $Ca^{2+}$ from brine and a maximum of 80 % reduction of $Ca^{2+}$ concentration in brine was observed within 48 hrs of contact time. All the tested strains of cyanobacteria showed a cyclic trend in their $Ca^{2+}$ uptake and release behaviour (see figure below). This process under the field condition (100 kg scale) resulted in 50 % less $Ca^{2+}$ in salt produced from sub-soil brine treated with Lyngbya aestuarii at 24.7 $^0$Be' (U. S. Patent Application No. 09/777664 dated 2 July, 2001). The process invented is an eco-friendly biological process requiring no additional chemical or energy input for operation.

Table 3. Reduction of calcium in subsoil brine using Lyngbya aestuarii

| Brine Density | $Ca^{2+}$ concentration (w/v) | | $Ca^{2+}$ concentration (w/v) | |
|---|---|---|---|---|
| | Untreated Brine | Brine treated for 6 h with MMGC | Salt from untreated brine | Salt from untreated brine |
| 24.7$^0$Be' | 0.12 | 0.05 | 0.31 | 0.14 |

The dark green mat-forming nature of the floating biomass in high-density brine could also enhance the rate of water evaporation from brine although this remains to be tested. The biomass could also be of value for recovery of certain pigments or application as aqua feed.

*Clockwise from top left. Filaments of Lyngbya aestuarii under the microscope; floating mass of Lyngbya aestuarii in brine; operations in the Experimental Salt Farm; salt obtained in the field through biological treatment.*

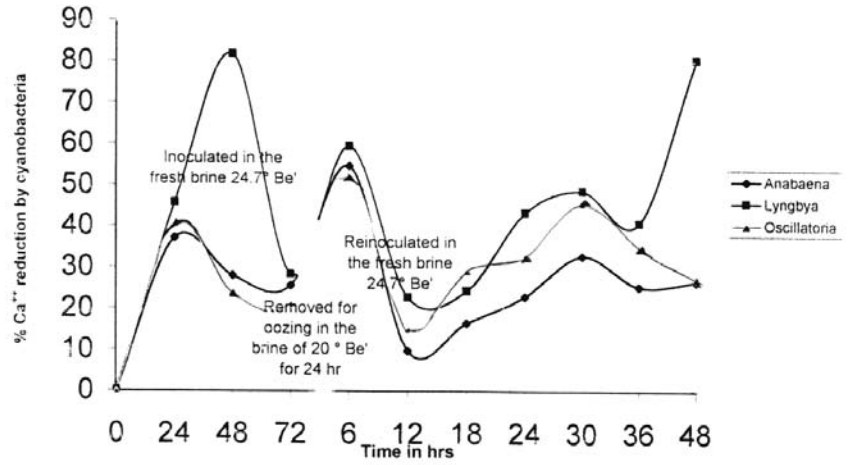
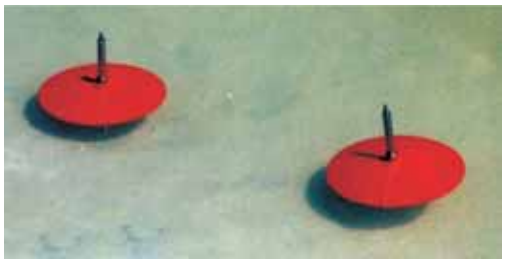



*Figure showing cyclic trend of cyanobacterial strains for uptake and release of $Ca^{2+}$ in brine. Anabena (circle); Lyngbya (square); Oscillatoria (triangle).*

## Quality control and improvement

**Device for measuring brine density from afar:** An innovative device for the measurement of density of brines in salt works from afar was designed, developed and tested in one of the major salt works at Port Victor. The device is designed to pop up from the brine once its density reaches 25.6°Be' so that the salt manufacturers have better control of brine charging into crystallizer to

minimize calcium impurity in industrial grade salt. Percentage of "off-spec" product has reduced considerably as a result.



*Device for Brine density measurement from afar*

**Upgradation of salt from Bangladesh:** Package information on 5 tph capacity mechanical salt washery for upgradation of solar salt from Bangladesh was supplied to M/s. Nuberg Engg. Pvt. Ltd., Noida. The raw salt analyzing 83-84 percent NaCl was upgraded to 98-98.5 percent NaCl. More than 80 per cent of calcium and magnesium impurities and insolubles were removed, in addition to colour, through the washing process developed. This upgradation of salt will make it possible to set up a caustic soda plant in Bangladesh.

**Salt cluster development for socio-economic benefit:** CSMCRI and SEWA (Self Employed Women's Association), Ahmedabad, have taken up a joint programme on improving the quality and yield of salt produced by the small and marginal salt workers (agarias) at Little Rann of Kutch (LRK) region. In the first phase, SEWA-CSMCRI combine has taken up 35 marginal salt works for quality upgradation. The agarias were trained on better methods of salt production and quality control. With this technical backing from CSMCRI, most of the agarias could produce industrial grade salt and SEWA could market the entire salt to user industries. SEWA-CSMCRI proposes to take up more salt works at LRK and integrating industrial grade salt production with the recovery of value added marine chemicals under a cluster development program.

**Salt works design:** A 10-acre solar salt works for the production of industrial grade salt from sea brine was designed and developed at Dharasana (Valsad District). The programme was sponsored by Rural Technology Institute of Gujarat, Gandhinagar. Industrial grade salt with < 0.1 percent Ca was produced in the salt works.

**Upgradation of gypsum:** A process for the production of cement grade gypsum from the raw gypsum crystallized at salt works during salt production was developed through mechanical washing. The washed gypsum analysed 0.5% chloride easily complying with the specifications for cement grade. The method gains further importance in view of the higher quantities of marine gypsum that will become available once the methodology of desulphatation of

brine is adopted by salt works.

Iodisation of salt: Iodate stability in iodised salt: Iodate stability of an improved salt manufactured by M/s. Hindustan Lever Ltd., Mumbai was studied under accelerated conditions and also under storage. These tests indicated significant improvement in stability of iodate in the salt.

Iodine test Kit: Kit for testing iodine in iodized salt in the field through improved methodology was developed. The improved method of testing can identify the possible adulterants in iodized salt. 200 such kits were specially made for UNICEF.

High purity potassium iodate solution for in situ iodisation of salt: A simple electrochemical process based on ion exchange membrane was developed for continuous preparation of high purity potassium iodate solution of appropriate concentration for direct iodisation in salt works. The outcome could lead to development of a process for manufacture of potassium iodate that would substantially reduce the cost of iodisation of salt.

*Iodised salt test kit*

## SILICATES & CATALYSIS

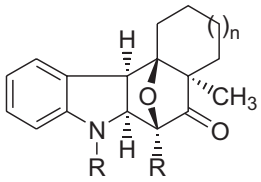
### Coordination Chemistry and Catalysis

Stereo-selective synthesis of epoxy-bridged molecules: A series of diazo carbonyl compounds tethered to substituted cyclopentanone and cyclohexanone units with different tether lengths have been synthesized using diazomethane or methanesulphonylazide. The above synthesized diazo carbonyl compounds with rhodium(II) acetate dimer furnish cyclic five- or six-membered-ring carbonyl ylide dipoles. These unstable transient species underwent facile 1,3-dipolar cycloaddition reactions with substituted/unsubstituted indoles, p-quinones, and symmetrical/unsymmetrical pentafulvenes to furnish various novel epoxy-bridged polycyclic systems. Very interesting structures such as decahydrobenzo[c]carbazoles 1, decahydrobenzo[a] carbazoles 2, oxatetracyclo[6.5.1.$0^{1,6}$.$0^{9,13}$]tetradecene 3 and several epoxy-bridged polycyclic molecules (e.g. 4, 5) have been synthesized. The unusual cyclization product, tri-oxapentacyclic compound 6 has also been synthesized and characterized.

The formation of unstable five- and six-membered ring carbonyl ylides has been demonstrated. The tandem cyclization-cycloaddition methodology has been developed to synthesize several new organic molecules. This methodology is particularly attractive as four chiral centers and two carbon-carbon bonds are formed in a single synthetic step.

## Inorganic metal complexes

**Solid state supramolecular structures:** The goal of crystal engineering is to rationally design supramolecular materials through understanding of non-



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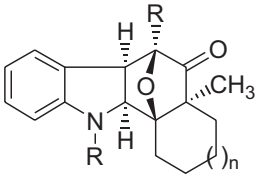

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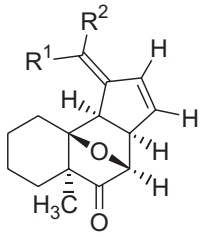

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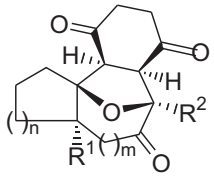

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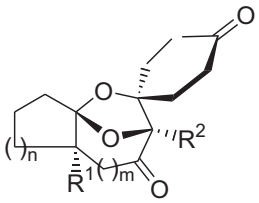

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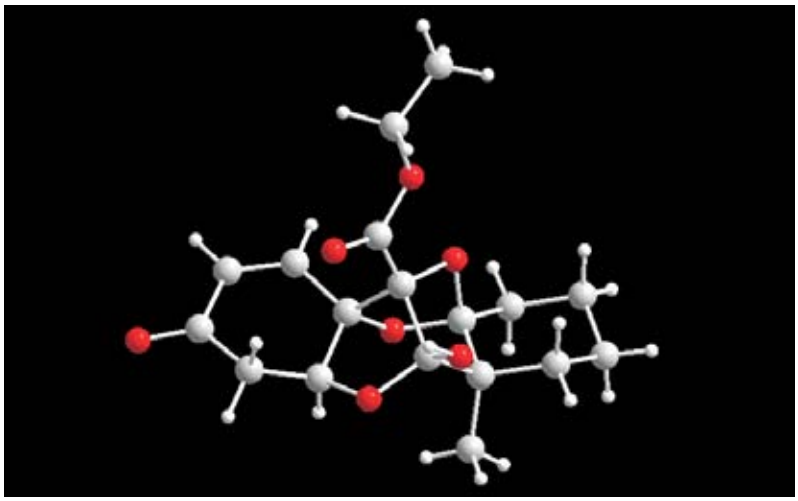


Tri-oxapentacyclic compound 6

bonding interactions such as hydrogen bonding, π-stacking, and halogen-halogen interactions. It has been realized in recent years that coordinate covalent bond formation through metal-ligand interaction is also a versatile

approach for forming supramolecular assemblies. Based on the information gathered from Cambridge structural database, motifs that can be used to glue the building blocks have been identified. In work carried out in the Institute, a Co(II) coordination polymer with 4,4'-bipyridine as rigid linker has been synthesized and structurally characterized (Fig.1). The polymer has a 2-D square grid architecture involving both coordinate covalent bond and N-H…O H-bonding interaction. A two dimensional H-bonded network based on an organic salt has also been characterized by single crystal X-ray diffraction technique (Fig 2).

**Binuclear Metal Complexes:** New ligand-4 (3,4-dihydroxy benzene) was synthesized, to investigate the effect of inclusion of bridging ligand on metal-metal interaction. New symmetrically substituted (trans) bis catecholate derivative of diphenyl porphyrin along with the monosubstituted catecholate derivative of tris phenylporphyrin have been synthesized. Corresponding mono and binuclear complexes of Ru(2,2'-bipy)$_2$(sq)$^+$ (sq is semiquinone) has also been synthesized and found to function as a redox switch. Also inclusion complex of ZnTPP with nitrobenzene as guest has been synthesized and single crystal X-ray structure has been solved.

Heterodinuclear complexes of Ru(II) and Os(II) were prepared using 2,4,6-

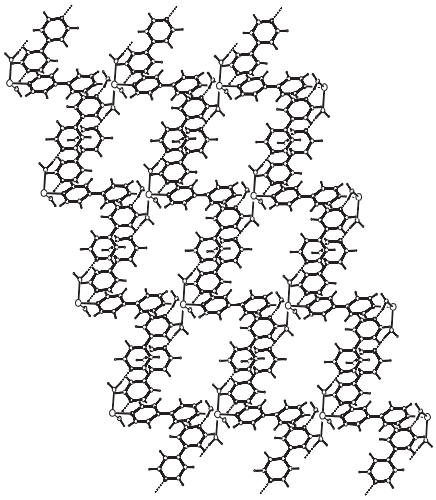


Fig.1. Pluton diagram showing the two dimensional H-bonded architecture in [Co(II)($H_2O$)$_4$(4,4'bpy)].($ClO_4$)$_2$. 4,4'bpy

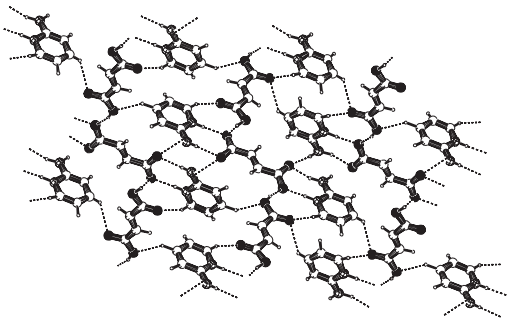


*Fig. 2. Two dimensional hydrogen bonded network in organic salt*

tris(2-pyridyl)-1,3,5-triazine ligand. Luminescence property of a series of mono-

, di-, and tetranuclear homo-/heterometallic complexes of Ru (II) and Os (II) with a designed polypyridyl based bridging ligand have been studied in various experimental conditions. Quantum yields of all these complexes have been calculated. The luminescence data suggest that in the heteronuclear complexes intramolecular energy transfer occurs from Ru (II) to Os (II) center through the bridging ligand.

**Chiral epoxidation of Indene and 6-cyano chromen with metal complexes:** Chiral epoxidations of indene (at 10 grams level) and 6-cyanochromene (at 5 grams level) were carried out using catalyst 1 (0.5-2 mol%), sodium hypochlorite as an oxidant and pyridine N-oxide (2-10 mol%) as an axial base in the temperature range of 0-4°C.

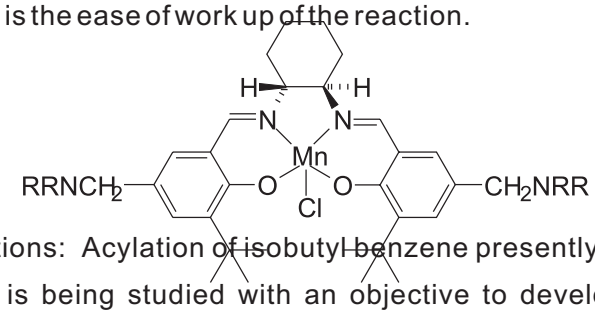
The catalysts used were modified versions of Jacobsen's chiral epoxidation catalyst, Mn(III)SALEN. Noteworthy features of the modified catalysts are: (i) The rate of reaction is 5-10 fold faster, largely due to the in-built phase transfer capability of the catalyst, (ii) the catalysts are effective in presence of cheaper axial base co-catalysts like pyridine N-oxide and 1,4-dioxane, while the original Jacobsen catalyst requires several folds of expensive 4-phenyl pyridine N-oxide or 4-(4-phenyl propyl) pyridine N-oxide, (iii) the catalysts could be recycled up to 5 times, with only minor loss in activity, and (iv) high conversion efficiencies. Optical purity of the cyanochromene oxide was >97%.

The dimeric homochiral Mn(III) and Ni(II) Schiff base complexes derived from Mono tartarate salt of (1R, 2R)-(-)-cyclohexane diamine with 3,5-di-tert-butyl salicylaldehyde and 3-tert-butyl 5,5-methylene-bis-salicylaldehyde were synthesized and used as catalysts for enantioselective epoxidation of chromenes, indene, styrene, t-3-nonene and t-4-octene, using, oxone and molecular oxygens as oxidant in presence of iso-butyraldehyde as sacrificial reductant. Near-quantitative conversions were obtained with all alkenes, and with high chiral induction in case of nitro- and cyano chromenes.

Dimeric Co(II) complex was used for hydro-kinetic optical resolution of epichlorohydrin, styrene oxide and propene oxide. The catalyst gave good yields of enantiomerically pure epoxides.

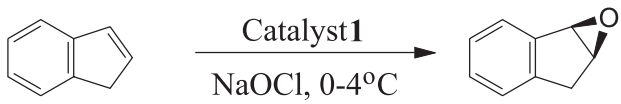
**Eco-friendly catalysts for synthesis of perfumery and pharmaceutical**

**a) Isomerization Reactions:** Longifolene isomerization to isolongifolene is carried out commercially with sulphuric acid. Solid acid based catalysts have been developed in collaboration with RRL, Jammu showing 96% conversion at 150°C and atmospheric pressure under solvent-free conditions. The advantage of the new process is the ease of work up of the reaction.

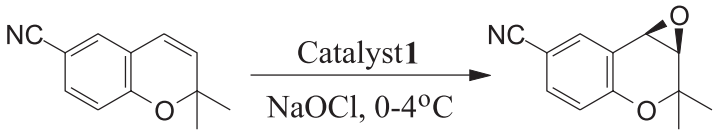



b) Acylation Reactions: Acylation of isobutyl benzene presently done using HF or $AlCl_3$ catalysts is being studied with an objective to develop eco-friendly

(*R*,*R*)-**1** Mn(III)SALEN, Catalyst **1**



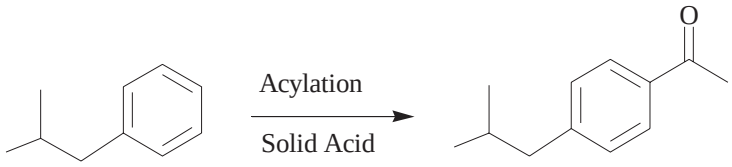

catalysts. Commercially available zeolites have been modified to function as




catalysts in the reaction and up to 32% conversion, with 92% selectivity for 4-Isobutyl acetophenone, has been achieved in laboratory experiments. The observed yield is substantially higher than that reported previously.

Zeolite and clay based catalysts have been developed giving more than 90% conversion for veratrole and 65% conversion for anisole. The process is solvent free using non-hazardous acylating agent and has high atom economy.


Longifolene Isolongifolene

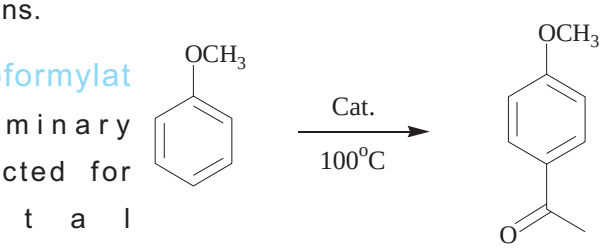



Iso-butyl benzene

4-iso-butyl acetophenone

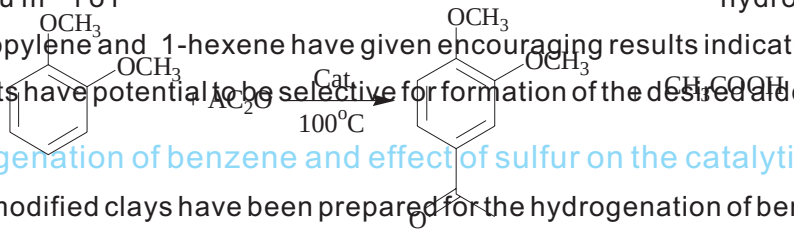
Synthesis of nanocrystalline solid super acids based on zirconia and triflates is being attempted. Sulfated zirconia having crystallite size as low as 8 nm has been obtained using the sol-gel technique and is being evaluated in acylation reactions.

**Hydroformylation of alkenes:** Preliminary experiments conducted for metal based on rhodium for evaluation of complexes ruthenium and hydroformylation of propylene and 1-hexene have given encouraging results indicating that the catalysts have potential to be selective for formation of the desired aldehydes.




Anisole

P-Methoxyacetophenone




Veratrole

3,4-dimethoxyacetophenone

**Hydrogenation of benzene and effect of sulfur on the catalytic activity:** Metal-modified clays have been prepared for the hydrogenation of benzene. The catalyst gave 100% conversion at high temperature and pressure but was very sensitive to sulfur compounds, as evident from rapid deactivation in the presence of 10-100 ppm of thiophene. Subsequent modifications have yielded catalysts with greater tolerance to thiophene and reasons for the higher sulfur tolerance are being ascertained.

## Inorganic layered and porous structures

**Preparation of upgraded detergent grade zeolite A of improved whiteness:** Zeolite-A technology released to M/S NALCO, Bhubaneswar through NRDC was successfully upgraded by improving the whiteness of the product. The 10,000 TPY plant based on bauxite leachate has been commissioned and the table below compares the properties of the plant product vis-à-vis specifications of internationally marketed products.

### Comparison of NALCO product with other internationally marketed products

### Novel Adsorbent for Oxygen, Nitrogen and Argon Separation from Air:

A novel zeolite-A based adsorbent for separation of oxygen, nitrogen and argon from air has been developed. Significant technical features of the adsorbent include:

- Almost 1.5 times higher adsorption capacity for $N_2$ compared to the best values reported previously for similar zeolites.
- Nearly threefold higher selectivity for nitrogen.
- First zeolite-A based adsorbent showing selectivity for Ar over $O_2$

A PCT patent application has been filed on the process of preparation of this adsorbent.

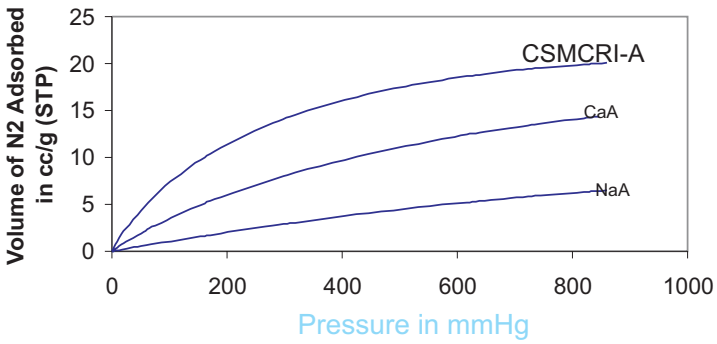
## Titanium Chemistry

| Sr. No. | Characteristics | Degussa | SPIC fine chem. | BIRAC | PQ Corpon. | NALCO Product |
|---|---|---|---|---|---|---|
| 1. | Ca binding capacity mg $CaCO_3$/ gm of absolute sample | 320 | 308 | 300±10 | 280 | 317 |
| 2. | Loss on ignition % at 800°C, 1hr | 21.5 | 21.5 | 20±1 | 20 | 21.5 |
| 3. | pH 5% aqueous slurry | 11.0 | 10.7 | 11.5 | 11.1-11.3 | 11.1 |
| 4. | Bulk density gm / cc | 0.56 | 0.62 | 0.50-0.55 | 0.30-0.40 | 0.51 |
| 5. | Average particle size $d_{50}$ in µm | 6.75 | 3.31 | 4.2 | 3-5 | <4 |
| 6. | XRD crystallinity (compared to BDH 4A powder) | 96 | 91 | 95±5 | Cryst. Structure cubic | 98-100 |
| 7. | Chemical composition<br>$SiO_2$ %<br>$Al_2O_3$ %<br>$Na_2O$ % | <br>31.7<br>29.7<br>16.2 | <br>32.2<br>29.7<br>15.9 | <br>42<br>35<br>23<br>on dry basis | <br>-<br>-<br>- | <br>33.3<br>28.85<br>16.31 |
| 8. | Whiteness index | 98.5 | 98.9 | 96±2 | White | >97 |

**Photocatalytically active surface for auto-cleaning of stained kitchen tiles:** Using binders like colloidal silica, zeolite-X and clay, ceramic tiles were coated with $TiO_2$ by a spraying technique. Strongly adhering coatings, tested by tip test and by washing with tap water, were obtained with (i) $TiO_2$ alone and (ii) with silica/$TiO_2$. In a series of experiments, spot tests were conducted on the coated tiles, using dye, chilly, turmeric and oil in various combinations. The tests showed that, under the influence of fluorescent light, dye spots were bleached within 4 hours, while spots due to spices were bleached in 10-12 hours.

## Waste utilisation

**Processing of by-product calcium carbonate:** A bench scale (10 kg/hr)




unit for processing by-product calcium carbonate has been installed at CSMCRI for preparing rubber grade and PVC cable insulation grade calcium carbonate.

Continuous Stirred Tank Reactor (CSTR) and Bubble Column Reactor (BCR) were designed and arrangements were made to measure various parameters. Experiments were conducted in BCR to optimize h/d ratio, superficial gas velocity and carbonation time. Relationship between superficial gas velocity and parameters such as reaction time, % $CO_2$ consumption and h/d ratio were established. The process was optimized to produce precipitated calcium carbonate with desired particle size distribution and crystallinity. Effect of additives like sugar, urea and surfactants on polymorphism and particle size distribution was also studied. Calcite was invariably formed during

*Spot tests on $TiO_2$-coated ceramic tile. The top portion was exposed to fluorescent light.*

carbonation and particle size distribution shifted towards higher size with addition of additives. A process flow sheet has been prepared for 100 tpd PCC production.

PVC pipes were extruded using PCC produced in the process and products of requisite specification were obtained. The PCC also meets the specifications for toothpaste and paint applications.

BENCH SCALE UNIT

**Palladium Recovery from Spent Silica:** Silica is used to purify a certain Pd-phthalocyanin complex. A part of the complex is irreversibly bound and therefore difficult to retrieve. At the request of a client, a process has been developed to effect recovery of Pd from the silica gel waste.

Extensive efforts led to a three step process for recovering Pd (as $PdCl_2$) in >95% yield and 99% purity without generating any waste. The process was scaled up to 10 kg scale of waste silica gel and successfully demonstrated.

**Feasibility studies on treatment of effluent generated in TDI plant:** The intermediates used to produce toluene di-Isocyanate (TDI) are dinitrotoluene (DNT) and meta toluene Diamines (MTD). The liquid effluent, which contains spent mineral acid and organic compounds is presently being incinerated at 1100°C. The feasibility of treating the effluents with different inorganic adsorbents was investigated to bring down the COD to acceptable levels. The approach is feasible, in principle. A photochemical method of treating the effluents was also studied.

CSMCRI

Biennial Report: 2000-2002

2

# POLYMER & MEMBRANE SCIENCE

**Conducting spacers in improving electrodialytic performance:** Conducting spacers are used to enhance the conductivity of diluate chamber in electrodialysis (ED). Each chamber carries an anion and a cation exchange membrane and a conducting spacer is interposed between the membranes. The use of conducting spacer reduces energy consumption and prevents change of pH. A systematic study of current-voltage curves of membrane, with or without conducting spacers, indicated the need to make use of two spacers instead of one in such a way that cationic membrane faces a conducting spacer of cation exchange material and anionic membrane that of anionic material. If they are interchanged one would end up with lower current efficiency and changes in pH. Though the use of conducting spacers is known, the way they should be combined was brought out in this work.

The use of conducting spacers extends the range of operation of ED. ED was used to desalt only up to 500 ppm and if one has to desalt beyond this, lower current efficiency is encountered and pH changes. With the use of conducting spacers it is possible to go far beyond 500 ppm (say 50-100 ppm), which means that products with much lower salt impurity can be obtained. The positioning of conducting spacers in relation to the type of membranes as indicated in the work extends the range of application of ED without any attendant pH changes. An example is desalting of amino acids to obtain amino acids with only 50 ppm salt.

**Development of technology/device for safe drinking water:** In continuation of on-going efforts towards development of new products for water treatment,a domestic electrodialytic water desalting unit and a 15 lit/hr defluoridation column were designed and fabricated. These are undergoing trials. These units can be used to convert brackish water to potable water and remove fluorides from drinking water. These units should have a direct bearing on the health of people.

Domestic Electrodialysis Unit

Except domestic units that are based on the principle of reverse osmosis (RO), commercial domestic water purifiers do not remove salt. ED systems are mainly composed of plastic material, simple electronic circuit for rectifier and inexpensive (non-high pressure) pumps. The units are

comparatively free from corrosion and easy to operate, with no moving parts. The suitability of the design for domestic ED desalting system is being tested to incorporate necessary changes.

**Development of a domestic defluoridating unit using ion-selective resin:** Presently techniques involving precipitation and adsorption are mainly being tried for defluoridisation with limited success. While in precipitation technique the treated water might have higher alkalinity, a soluble complex of aluminium fluoride might get formed in adsorption technique. The regeneration of exhausted bed would have lower treatment (defluoridation) efficiency. The technique using ion-selective resins is free from such problems.

The resin originally developed for secondary purification of brine in chlor-alkali industry -- for making caustic soda and chlorine by membrane technology -- has been used for this additional application through suitable chemical modification.

**Development of brine purification resins:** For the first time, a brine purification resin that is non-styrenic and totally aliphatic in nature has been developed. It does not involve the conventional chloromethylation route for functionalisation, which requires highly carcinogenic chemicals. Aminomethyl phosphonic acid type resins are more specific for alkaline earths than iminodicarboxylic acid type resin currently being used in the industry. Such resins are useful for final polishing of brine to remove last traces of alkaline earth metal ions ($Ca^{++}$), i.e., to <20 ppb, before charging it to the membrane cell for alkali production.

Gujarat Alkali & Chemicals Ltd., (GACL), Baroda is assisting in the scale up of resin synthesis and point of use testing of the resin at their plant at Ranoli, Vadodara.

**Parametric study of polysulfone membrane:** Ultrafiltration membrane prepared from polysulfone and other membranes are widely used for different separation/concentration processes in chemical, food processing and pharmaceutical industries. These membrane based applications would increase sharply due to the inherent process advantages like operation at ambient temperature, easy but reliable operation, low energy requirement and environment friendly nature..

Polysulfone (PS) support membrane commonly used for composite membrane development is hydrophobic in nature, and poses certain difficulties such as

greatly reduced flux when the pore size is reduced beyond a point. As an alternative, it has been possible to make porous membranes from polyether sulfone (PES) on a small scale. PES is hydrophilic, cheaper, indigenous and easily available while possessing all other propreties of PS such as high thermal stability ($T_g$ = 225C) and high chemical stability. Basic studies on pore size/ pore distribution for polysulfone (PS) and polyether sulfone (PES) using porometer have been carried out. The studies provided information on size of pores, variation in pore size, density of pores (when prepared under different control condition), etc. As a first step, casting experiments were carried out on a glass plate for developing small support membranes. These menbrane coupons were then evaluated for determining pure water permeability (PWP) constants and characterized for pore size distribution studies. The initial results indicate that pure water flux is appreciably higher than for PS while the pore measurements are appropriate for composite membrane development. Efforts are on to develop PES membranes on a large scale while optimizing the casting conditions before establishing the efficacy and advantage of PES for TFC membrane development.

## Surface modification of membranes for the minimization of fouling:

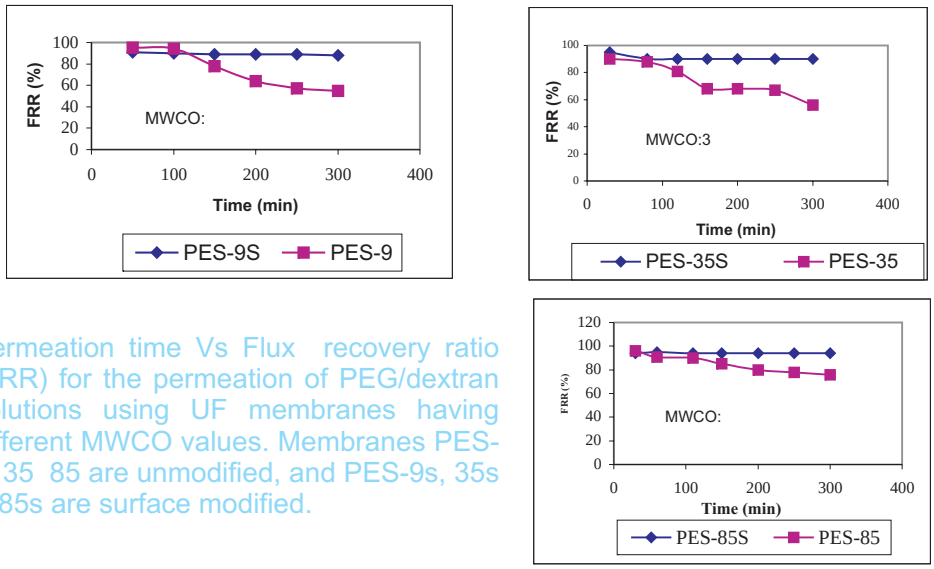
Polyethersulfone ultrafiltration membranes were surface modified by preadsorption of polymers containing hydrophilic functional group. The surface chemistry of the modified membranes was identified by FT-IR spectra. The pore sizes of the membranes were determined by bubble pressure porosimeter and gel permeation chromatography. MWCO values and fouling resistance nature of the membranes were measured by permeating 500-2000 ppm aqueous feed solutions of different molecular weight PEGs, dextrans and bovine serum albumin.

Several surface modified polyamide composite membranes were prepared by in situ formation of polymers containing hydrophilic functional group like sulphonic acid and carboxylic acid under different conditions. The performances of the modified and unmodified membranes were measured using aqueous feed solutions of 30000 ppm NaCl at 900 psi and 2500 ppm NaCl at 250 psi for longer duration of time to obtain information about fouling resistant nature of the surface modified membranes.

The surface modified membranes have shown good resistance to fouling by organic solutes as indicated by their water flux recovery ratio values (Figure 1) after the permeation of different solutes.

## Development of concentrator for herbal/ plant extract concentration:

Current practice of concentrating herbal or plant extracts is through rota-evaporation. It is very time consuming and often affects biomolecules due to higher temperature of operation thus inhibiting proper concentration of plant extracts. The membrane based plant extract concentrator, on the other hand, overcomes this limitation as it operates at ambient temperature and the process of dewatering is much faster. The equipment would thus be very handy for studies involving large number of aqueous plant extracts.




Permeation time Vs Flux recovery ratio (FRR) for the permeation of PEG/dextran solutions using UF membranes having different MWCO values. Membranes PES-9, 35 85 are unmodified, and PES-9s, 35s & 85s are surface modified.

The concentrator is based on Polysulfone-Polyamide (PS-PA) thin film composite membrane and removes only water from the extracts. The dimensions of the cartridge used are 5 cm x 30 cm. Up to 3 litres of aqueous extract can be concentrated by as much as 75 percent in less than two hours. The removal of water, however, is partly dependent on the concentration and the viscosity of the herbal/plant extract. An added advantage is that unlike a rotavapor this equipment avoids formation of froth thereby eliminating the need to remove the same and enhancing efficiency.

Aqueous Herbal Extract Concentrator

The concentrator has been specially developed for the CSIR inter-laboratory programme on drugs. The concentrator was demonstrated to the participating laboratories and has been very well accepted. Thirteen units have so far been supplied to the laboratories participating in the Inter Laboratory Coordinated CSIR programme

on "Discovery, Development and Commercialisation of New Bioactive and Traditional Preparations".

**Development of 20 cm x 1 meter spiral element for large scale desalination plant:** The 20 cm diameter spiral module is currently the world standard in RO plants. This development would enable us to manufacture large scale desalination plants at a lower capital cost and as a result the product water cost will also be significantly reduced. Besides being useful in providing potable water this achievement would also be useful in treating waste water in refineries, fertiliser and power plants ensuring water reuse concurrently reducing to a large extent the effluent problem.

Spiral element of 20 cm diameter and 1meter length, based on Thin Film Composite (TFC) polysulfone-polyamide (PS-PA) membrane, has been developed. Each spiral element would accommodate 39 sq. meter membrane area and produce about 20,000 liters/day output under standard test condition and remove 95 percent of salt.

Financial support has been received from Chennai Petroleum Corporation Ltd. (CPCL). Large scale trial is being conducted at their premises. The Centre for High Technology (CHT) has also approved funding for a 1MLD capacity plant.

**Community type RO desalination unit:** A large part of our country's population has to depend on underground water for drinking. Often such water sources are brackish and could not be used for drinking directly. To render such water suitable for drinking, especially in small communities a 100 litre/hr desalination system based on RO has been designed and a few units have been fabricated and installed in Kutch district of Gujarat.

The unit developed is suitable for converting saline (brackish) water having a maximum of 5,000 mg/liter of total dissolved solid (TDS) to high quality product water with 500 mg/liter TDS. The process also eliminates bacteria present in the feed water. The unit has been designed for both single-phase and three-phase power supply. It consumes 1.2 KWH power and is ideally suited for use in schools, offices, banks, hospitals, small industries, and small hamlets.

The unit employs two modules (30cm diameter x 1 meter) made of CSMCRI's thin film composite (TFC) membranes and operates in the range of 10 $Kg/cm^2$ to 15 $Kg/cm^2$ pressure depending on the feed water quality. Three such units are operating, two with the Vivekananda Research & Training Institute, and one with SRUJAN (a voluntary organization), all in Kutch district of Gujarat, and are

funded by these organizations.

Community type RO unit (100 L/h)

**TFC membrane development for removal of fluoride from drinking water:** In yet another approach, application of membranes for removal of fluoride from water was studied with a loose negatively charged TFC nano-filtration (NF) membrane. Defluoridisation experiments were conducted on a test kit with pure water, tap water and hard water into which sodium fluoride (NaF) was added. The studies indicated that poly-piperazine amide based NF membranes could be used to reduce fluoride content. In fact these membranes are capable of achieving 50 to 85 percent removal of fluoride depending on the feed water type and operating conditions. Incidentally, these membranes could also remove NaCl to the extent of 30 to 35 percent from saline feed water (0.1-0.2%). Hardness removal by these membranes was about 70 to 75 percent.

# 3

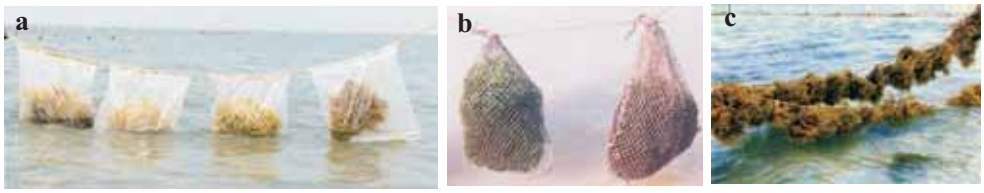
# BIOSALINITY

# MARINE ALGAE

## Seaweed cultivation and value addition

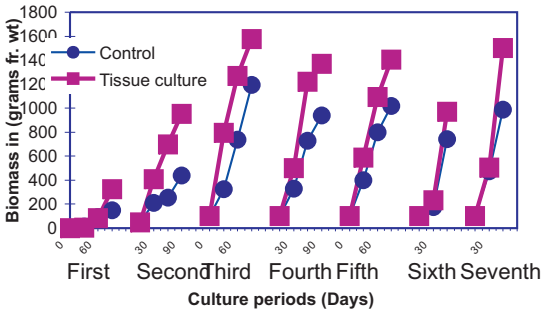
**Eucheuma:** Eucheuma is the single most important source of κ-carrageenan. This alga has been extensively farmed in the Philippines, Indonesia and Tanzania. CSMCRI has successfully introduced this seaweed in Gulf of Mannar and developed different methods of cultivation in bags and in the open sea. Polythene bags were found to be the best for maintaining germplasm for seeding purpose, whereas open cultivation on rope was found to yield the highest biomass, in absence of grazing. Bags made from fishing net were useful when the sea is rough. Besides eliminating the problem of seaweed loss due to detachment and drifting, it also reduces grazing without excessive hampering of growth. By increasing the number of bags and reducing the harvest period from 90 days to 45 days, it has been possible to obtain yields as high as 9-12 tonnes/ha/year based on field data in Thonithurai. The yield was even higher in Krusadai island whereas the Palk Bay side was generally less conducive for growth. These results compare favorably with cultivation data elsewhere, as indicated by international experts. The promising findings have enabled the Institute to transfer know how to Pepsico Holdings India Ltd. who are initiating commercial scale cultivation of seaweed for the first time in India.

Besides developing improved farming methods, the germplasm has also been




Cultivation of Eucheuma in (a) polythene bag, (b) fishing net bag and (c) on rope.

improved through tissue culture technology involving somatic embryogenesis. The figure below summarises the key steps of the process. The tissue culture seedlings adapted well in the sea and exhibited 1.3-1.8 times the growth rate of the conventional Eucheuma in studies carried out over several generations. Yield and quality of refined carrageenan obtained



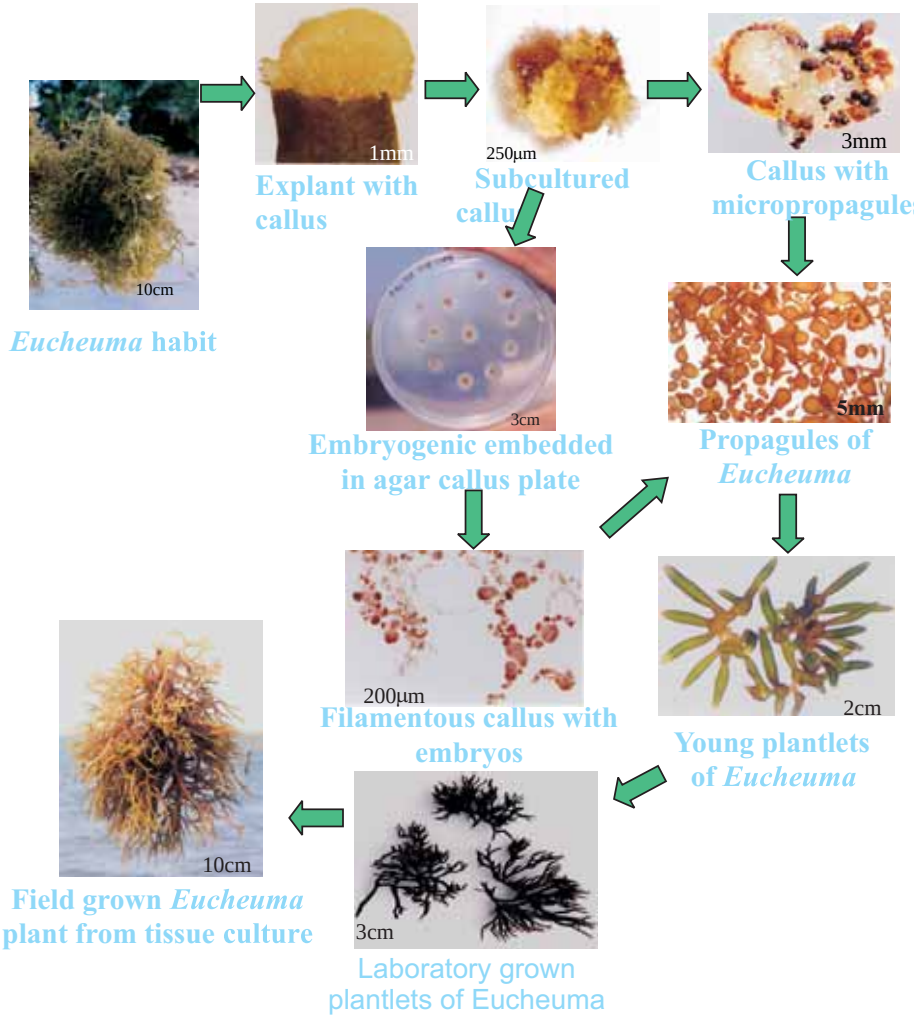

Growth of conventional and tissue cultured Eucheuma in field cultivation

from the tissue cultured seaweed were found to be satisfactory. The tissue culture method can also be used to mass produce seed stock.

The process for manufacture of semi-refined κ-carrageenan from Eucheuma

Eucheuma farm of Pepsico Holdings Ltd. at Thonithurai, Gulf of Mannar

has been further improved and scaled up in the pilot plant. The usage of water




Somatic embryogenesis and clonal propagation of Eucheuma

has been minimized and a simple method has been developed to recycle the alkali required in the process. The process for refined κ-carrageenan has also been improved. A new approach is also being experimented with to dispense with the use of alcohol.

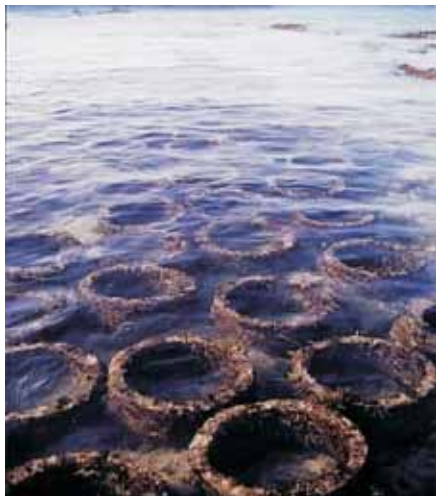
Besides the conventional use of Eucheuma as a source of kappa-carrageenan, the remarkable ability of the seaweed to accumulate large amounts of potassium ion from seawater has been exploited in development of "bio-potash".

κ-Carrageenan production

Gelidiella acerosa: Cultivation of different strains of Gelidiella acerosa on coral stone was continued to identify Gelidiella acerosa having superior growth, agar yield and gel strength. The data on biomass yields indicated that the plants collected from CSMCRI farm, Kilakkarai and Sethukarai exhibit higher yields than those collected from other places. Yield of agar and gel strength were the best for CSMCRI farm material, confirming its overall superiority. This germplasm has, therefore, been selected as seed stock for scale up of Gelidiella cultivation. For maximizing the biomass yield, studies were also conducted at different seeding densities (200, 300, 400, 500 and 600 g/m$^2$). Seeding density of 400 g/m$^2$ yielded an optimum average biomass of 2.31 kg/m$^2$ for first harvest and 1.15 kg/m$^2$ for the second harvest. Studies were also carried out on different types of artificial substrata. Based on the above studies, hollow cylindrical cement blocks were fabricated and 6000 such blocks were seeded with CSMCRI elite germplasm after conditioning in the sea.

It has now been possible to produce superior quality bacteriological agar indigenously from the Gelidiella acerosa cultivated in the CSMCRI farm. Bacteriological agar is used in clinical applications, auxotrophic studies, bacterial and yeast formation studies, bacterial molecular genetics applications

as well as in mammalian and plant tissue culture. In India, the requirement of bacteriological agar is met largely through imported products at a very high cost.



Left: Hollow Cylindrical I cement blocks left for conditioning in the sea and Above: Close-up view of Gelidiella acerosa seed on cement block.

The method of production involves: pressure extraction of agar from the seaweed after suitable pre-treatment. The resulting liquid agar extract is filtered and clarified, and then subjected to freeze-thawing to further refine the product. The agar flakes obtained after drying are powdered to yield bacteriological grade agar conforming to international specifications. The process has been scaled up to 1.5 kg of dry seaweed/batch. The yield of agar is in excess of 25% (based on bone dry seaweed). The product has been found to have gel strength in excess of 600 g/cm$^2$ under standard conditions of measurement (1.5% gel; 20°C). This development is partially funded by the Department of Biotechnology and industries.

Sulphated polysaccharides: A method of assaying sulphated polysaccharides (SPS) was developed. The extract was purified by ion-exchange and gel column chromatography. Alditol acetates of purified sulphated polysaccharides were prepared and the carbohydrate monomers present in the latter were identified and quantified by GC-MS analysis.


Evaluation of CSMCRI's bacteriological agar (1%) in DNA gel electrophoretic study. Digested DNA along with a marker (1 kb Gene Ruler, MBI Cat No SM 0313 ) were run (Electrode buffer : 1X TAE, 75 volt current ) for 1 hr. The gel slab was seen under UV transilluminator and photographed in Gel Documentation Unit (Pharmacia Biotech). Satisfactory migration of DNA is observed. (Courtesy: Indian Institute of Chemical Biology, Kolkata).

Continuing studies on Codium dwarkense, a green algal species that was earlier shown to have blood anticoagulant activity, indicate that the activity of the aqueous extract peaks during the sporulating period.

Liquid seaweed fertilizer (LSF): Chemical compostion (N P K and trace elements) of different brands of LSF was compared with that of CSMCRI LSF. The data indicates that the latter is comparable to other brands. Different Sargassum sp. were analyzed for their LSF value in order to select the best one characterized by maximum total dissolved solids (TDS). Sargassam swartzii was found to contain highest TDS (12.9 percent). Different methods were adopted to prepare the best quality LSF with maximum manural elements. Sargassum mixed with Ulva in the ratio of 75:25 resulted in an increase of N:P:K content to 3.75 %, 3.10 %, and 0.12 %, respectively, from the previous concentrations of 2.5 %, 2.5 %, and 0.085 % when Sargassum alone was used. Field trials were conducted at Biovillage, Mocha on onion. An increase of 16 % in production of bulbs at 10 percent concentration of LSF against control was observed. Application of L.S.F. on onion crop at Lakhanka village, Bhavnagar showed an increase of 17-29 % in the yield of onion bulbs, when sprayed with different concentration of LSF. The effect of soil application of LSF on Jojoba seedling showed increase in height and number of branches by about 50 percent. Field experiments were also conducted on wheat and groundnut and positive effects observed.

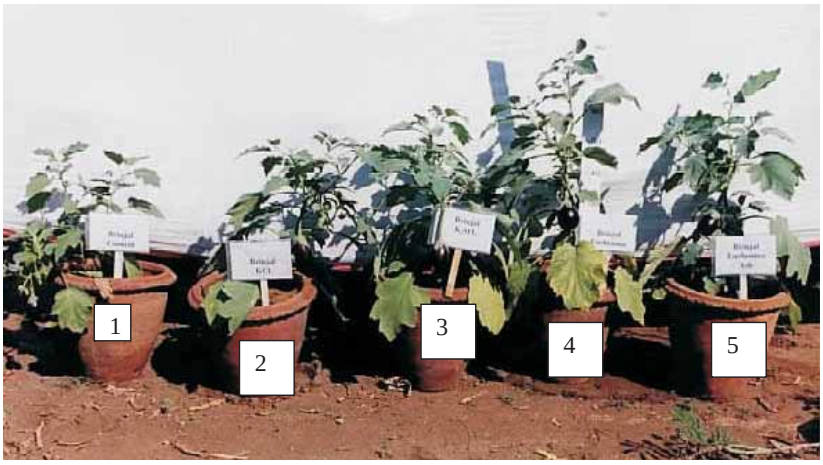
Biopotash: Use of Eucheuma as a source of potash was studied in detail. Both Euchema and Euchema ash when applied to brinjal and wheat recorded 33 and 42 percent higher yield, respectively. Effect of foliar application of Eucheuma sap on growth and seed yield of 75 days old Vigna radiata (green gram) plants was also studied. Treatment with 10 percent (v/v) sap concentration produced about 50 percent higher seed yield. Use of lower or higher percentages of sap had lesser effect.

Effect of LSF on production of Onion bulbs

Microbial Systems: A protease-producing marine bacterial culture was isolated. Eighty fold purification of extracellular protease was achieved by ammonium sulphate precipitation, column chromatography and gel filtration.

Operational stability of the isolated protease could be improved by its immobilization on κ-carrageenan. The immobilized enzyme retains almost constant activity when the samples were stored at <15 $^{o}$C for 20 days. (Free enzyme loses its activity within 2-3 days under similar conditions of storage.) It was also observed that immobilized enzyme could be used six to eight times without appreciable loss of activity towards casein degradation.

**Biological treatment of effluent:** Bacterial and fungal cultures were isolated from a dye industry effluent and both were used independently for effluent treatment. Reduction in COD up to 90 % was observed within 15-16 days with the




*Effect of Muriate of potash, Sulfate of potash, Eucheuma powder and Eucheuma Ash (2nd to 5th ) on vegetative growth of brinjal at similar $K_2O$ levels. The plant at the extreme left was cultivated without any application of fertilizer.*

bacterial culture, whereas the fungal culture showed no significant reduction in COD. Decolorization studies carried out using both the cultures revealed that the fungal culture was effective in reducing the color of the effluent by 60-65 %.

Three different bacterial cultures were isolated from an industrial effluent released by manufacturer of a fungicide. Reduction in COD up to 88 % was observed when the cultures were applied in the form of a consortium.

Liquid effluent from a dye industry was subjected to electrochemical oxidation to destroy the chromophoric group and thereby reduce colour. The effluent was then subjected to microbial degradation in presence of a bacterial culture and the COD reduction was nearly quantitative within 16 days.

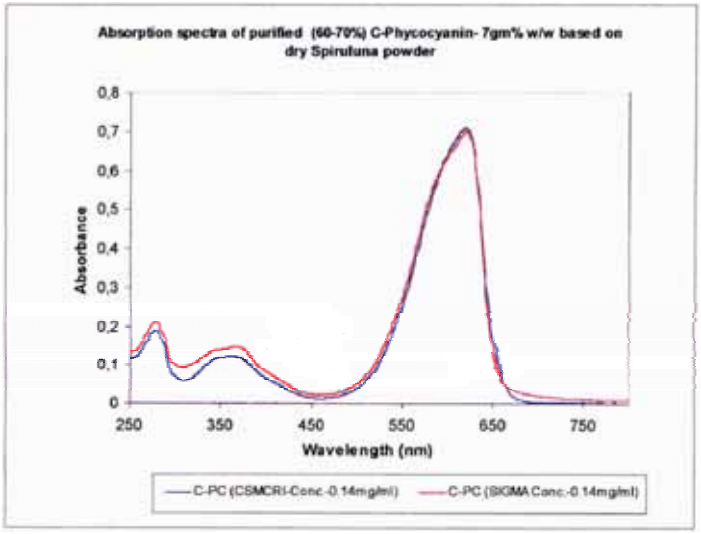
A cyanobacterial consortium employed in the form of a mat was utilized as a biofilter to treat a variety of highly saline effluents. 60-80 % removal of color was observed.

**Biopigment:** A method has been developed for the production of the high value

fluorescent pigment, C-Phycocyanin (C-PC), from a strain of Spirulina platensis. Important innovations in the protocol for cultivation, harvesting, extraction and purification have yielded high purity C-PC with 10% yield on dry weight basis. As can be seen from the absorption spectral data below, the CSMCRI product has similar absorbance at 620 nm as the product from Sigma, when both spectra are recorded with similar concentrations of C-PC (0.14 mg/mL). The ratio of absorbances at 620nm & 280nm, which indicates the extent to which protein impurities are present, is also comparable for the two products.

A key factor behind the high purity of product obtained is membrane processing of crude extract. The membrane of appropriate M.W. cut off developed for this purpose in the Institute enabled the undesirable low M.W. proteins and other impurities to be eliminated. The process also led to dewatering of the extract by up to 80% thereby reducing the load on the lyophiliser considerably. A technique was developed for preparation of monoclinic single crystals of C-PC and the crystal structure has been obtained through X-ray diffraction with 3 Å resolution.

## PHYTOSALINITY

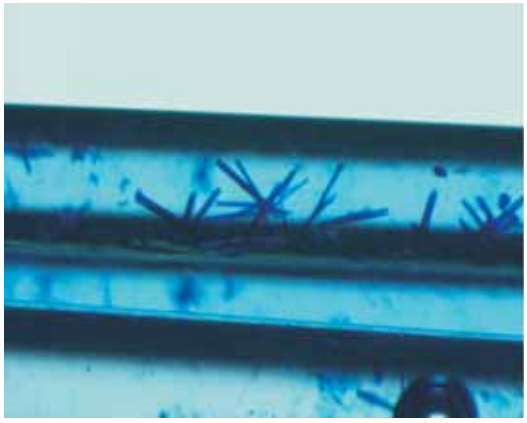



**Salt tolerance mechanisms in Halophytes:** Salt tolerance mechanism in Salicornia brachiata was studied. Tissue specific compartmentalization of ions, alteration in enzymatic activities and increased succulence were proven to be important factors in salt tolerance of halophytes. Comparison of salt tolerance of cell cultures with that of whole plant revealed that anatomical complexity and physiological integrity play critical roles in salt tolerance. Remarkably, S. brachiata does not distinguish between NaCl and NaBr and both these salts are

| Membrane[1] | MW cutoff | flux (gfd) | % removal of other protein | Purity ratio ($A_{620}/A_{280}$) after ultrafiltration |
|---|---|---|---|---|
| PES-16 | 85,000 | 68 | 4.5% | 0.13 |
| PES-18 | 9,000 | 22 | 1.7% | 0.05 |
| PES-26 | 35,000 | 55 | 32% | 0.91 |
| PES-29 | 40,000 | 130 | 25% | 0.72 |
| PS-$A_1$[2] | Surface modified membrane | 170 | 34% | 1.05 |

[1]PES = polyether sulphone; PS = polysulphone; [2]PS-$A_1$ = polysulphone low protein binding microfiltration membrane

accumulated in the plant. Tolerance limit and distribution pattern to these salts



Crystals of c-phycocyanin grown using hanging drop method. Condition: pH 6.5, 0.1M phosphate buffer, PEG 4000 and 8000, 10% each. Cryoprotectant 30% PEG600. Single crystal XRD of the protein crystal indicate the following Unit Cell dimensions: a = 107.39, b = 115.77, c = 183.30 Å, á=ã=90º, â=90.06º; Data: 40-3.0Å, Rmerge = 7.7% (17.5 in last shell)

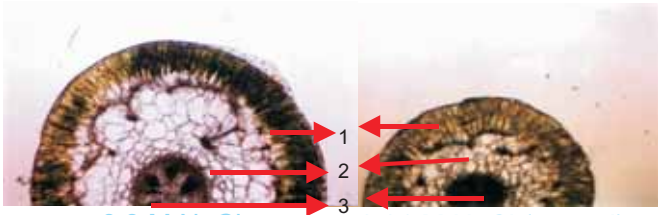
were studied using SEM and EDAX. At equimolar concentrations of NaCl and NaBr, the accumulation of the bromide salt was 60 percent and chloride was 63 per cent, on dry weight basis.

If plants avoid injury by compartmentalization of toxic ions and increase in succulence, an understanding of the mechanism by which this is accomplished would be of immense practical importance. The results from the research will increase our understanding of how such plants use $Na^+$ as a signalling molecule to stimulate the activity of transport protein. This protein sequesters $Na^+$ from salt sensitive metabolic machinery and increases succulence, preventing dehydration of tissue from increased solute accumulation. The results will permit novel molecular biological approaches towards improvement of responses to salinity in crop species.

Compartmentalization of $Na^+$ and $K^+$ ions in different tissue layers of Salicornia brachiata ( mg/g ash wt.)

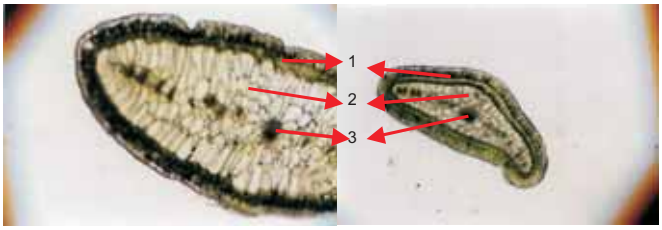
**Cultivation of Salicornia brachiata in coastal saline soils:** Salicornia brachiata is a source of edible oil rich (>75%) in linoleic acid. Its cultivation on highly saline soils using saline water as an irrigant was undertaken in ex situ

conditions, using wild germplasm from Gogha and other coastal locations of Saurashtra. A few high-yielding plants were selected from the trials conducted. These plants were grown in separate plots to assess the biomass production and yield. The seed yield per plant as well as the unit area yield were found to be higher than in the naturally growing population and the results were confirmed to be statistically significant. Morphological variations, e.g., color, number of




1. Palisade 2. Mesophyll 3. Vascular; Magnification 100X

Effect of salinity on succulence development in Salicornia brachiata




1 Palisade 2 Mesophyll 3 Vascular; Magnification 100 X

Effect of salinity on Succulence development in Suaeda nudiflora

spikes & segments per plant, and spreading nature, were also identified in the ex situ trials. GSFC Science Foundation, Vadodara is supporting the programme, in

| Tissue layer | $Na^+$ | $K^+$ | $Na^+/K^+$ |
|---|---|---|---|
| Palasade | 263.39 | 68.40 | 3.85 |
| Mesophyl | 365.09 | 58.63 | 6.22 |
| Vascular | 149.53 | 76.61 | 1.93 |

view of the considerable potential for coastal saline wasteland development.

**Edible oil from Salicornia:** As mentioned above, Salicornia is a useful source of edible oil rich in linoleic acid. Salicornia plant seeds are small in size and recovery of the oil by conventional expelling is difficult. Solvent extraction of oil is possible but it inevitably leaves traces of solvent in the oil. Using the $CO_2$ supercritical fluid extraction (SFE) technique (courtesy IIT Bombay), 1.125 kg of Salicornia seed was processed for 2 hours at 300 bars pressure and >85 percent of the oil in the seed could be recovered. Further work on fractionation is being carried out.

Plant salt: A new concept of vegetable salt was conceived and a proprietary process has been developed for the preparation of nutrient-rich salt from certain halophytic oil-bearing plants that have a propensity to accumulate salt within their tissues. Salicornia is one such plant. Fine white crystalline and free flowing

edible salt can be obtained, which contains, in addition, 5-15% potassium chloride and several important micronutrients, e.g., Fe.

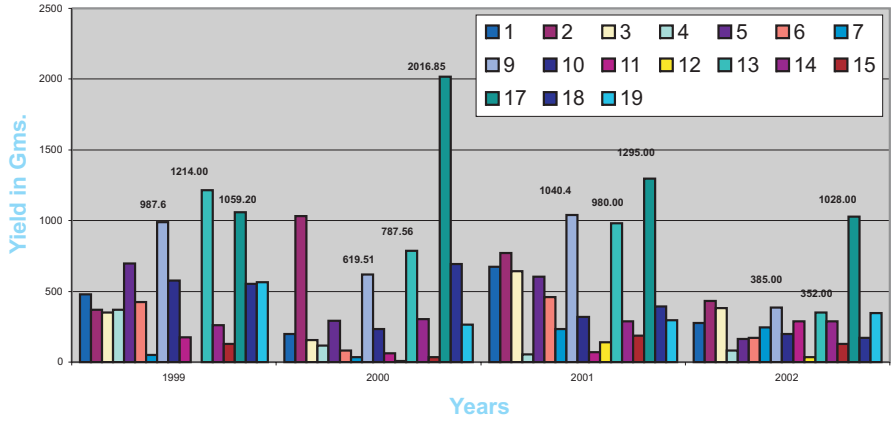
Salicornia oil through supercritual fluid extraction

Jatropha Cultivation: Jatropha curcas is a non-browsable perennial shrub wildly growing all throughout India, but especially prevalent in arid and semi-arid regions of the country such as Gujarat, Rajasthan and Andhra Pradesh. Its seed is a source of non-edible oil rich in oleic acid (60-70%). Currently there is intense interest in this plant as a potential source of biofuel from eroded land. Data obtained from CSMCRI's germplasm pool of Jatropha curcas raised in the Berhampur Field Station indicate that there is one plant, in particular, that gives consistently high yields of seeds. Attempts are being made to propagate this plant both vegetatively and through micropropagation. Although multiple shooting is obtained in in vitro conditions, the further organogenesis of the shoots has not been achieved so far.


Vegetable Salt

Non-toxic genotype of Jatropha curcas: Seeds of Jatropha obtained from indigenous plants is toxic because of the presence of phorbol esters. Studies were carried out with a non-toxic strain raised from seeds containing very low amounts of phorbol esters. The table below shows the phorbol ester contents of various seeds. Seeds from indigenous plants have phorbol ester content of ca. 3.7 mg/g which is considerably higher than the values (2.87 3.07 mg/g) previously reported

anywhere (information courtesy Professor K. Becker, University of Hohenheim, Germany). In contrast, the seeds harvested from the plants raised in the




CSMCRI experimental site from toxic seeds had phorbol ester contents ranging from 0.06 0.11 mg/g. Thus these plants have retained their non-toxic nature even under the prevailing conditions at Bhavnagar. This may lead eventually to production of edible oil from the oil and utilization of oil cake as feed.

Left: Shoot Primordia from Leaf callus ; Right: Shoot Emergence

## Tracking the performance of CSMCRI's Jojoba cultivation at Zanjmer :

A study has been conducted to ascertain the consistency of performance of progeny plants of Jojoba raised at CSMCRI's experimental cultivation site at Zanjmer. As can be seen from the table below, data on 14 elite female genotypes indicate an average yield of 1.5 kg seed/plant in the years 2000 and 2002. This compares favorably with the corresponding yields extrapolated from information obtained from the International Jojoba Export Council (IJEC). The poor yield in 2001 would make it evident that environmental factors are equally important.

To popularize the elite germplasm, it is necessary to mass propagate the plants, e.g., through stem cuttings and tissue culture. An added advantage would be that the seedlings would be of known sex that would facilitate a planned design of the farm. In the present work basal media reported earlier for micro-propagation has been modified to improve the multiplication rate. The composition of root inducing auxin mixture has also been modified. The technology will provide

| Seed Source | Phorbol ester content in seed (mg/g)[1] |
|---|---|
| Ambaji, Gujarat | 3.71 |
| Mahuva, Gujarat | 3.70 |
| Raised from non-toxic seeds: | |
| Plant 1 | 0.067 |
| Plant 2 | 0.081 |
| Plant 3 | 0.111 |
| Plant 4 | 0.088 |

[1]Analysed at University of Hohenheim, Germany

high quality known sex seedling of Jojoba at faster rate and help optimize the male- female ratio in planned cultivation. Known sex CSMCRI elite Jojoba clones raised through in vitro propagation methods, and planted at AJORP farm (Dhand, Jaipur), has been found to be performing at par with the best of Israel clones, and has begun to bear fruits from 3rd year onward. This indicates that the domesticated CSMCRI selection of Jojoba will adapt better in Indian conditions.

Data on Worldwide Jojoba Cultivation and Seed Production along with data on relative productivity of CSMCRI elite plants during 2000-2002

**Isolation of New Organic Molecules from plant sources:** Many nontraditional plant species, hitherto unexploited but highly suitable for marginal wasteland, are being explored for their medicinal potential under the CSIR inter-laboratory programme on Bio-actives from plant sources. Positive assays are confirmed both in vitro and in vivo for several plant extracts provided by the laboratory. Based on these leads, discovery groups have been formed for filaria, tuberculosis and malaria.

## MARINE ENVIRONMENT

**Seaweed Biodiversity:** A revised checklist of seaweeds occurring in the Indian coast has been compiled. Of the total 844 species recorded, 434 belong to Rhodophyta, 216 to Chlorophyta, 191 to Phaeophyta and the remaining 3 to Xanthophyta. The checklist provides detailed information on each species, forma and varieties, their occurrence at different localities on Indian coast, details regarding type specimens of each species and updated references of

papers published on varied aspects, including: biology, culture, cultivation, chemistry and utilization.

| Sr. No. | Country[1] | Total Area[1] (ha) | Total Seed Production (MT) | Productivity (Kg per ha)[2] | Yield per Plant (kg) |
|---|---|---|---|---|---|
| 1 | Israel | 600 | 1000 | 1666.66 | 1.67 |
| 2 | USA | 2240 | 1455 | 649.55 | 0.72 |
| 3 | Mexico | 310 | 90 | 290.32 | 0.32 |
| 4 | Argentina | 3400 | 950 | 279.41 | 0.31 |
| 5 | Peru | 300 | 75 | 250.00 | 0.28 |
| 6 | Egypt | 140 | 15 | 107.14 | 0.12 |
| 7 | Australia | 400 | 8 | 20.00 | 0.022 |
| 8 | CSMCRI[3] | | 0.02153[4] | 1195.58 | 1.54[4] |
| | | | 0 .00276[5] | 153.38 | 0.20[5] |
| | | | 0.02152[6] | 1195.00 | 1.54[6] |

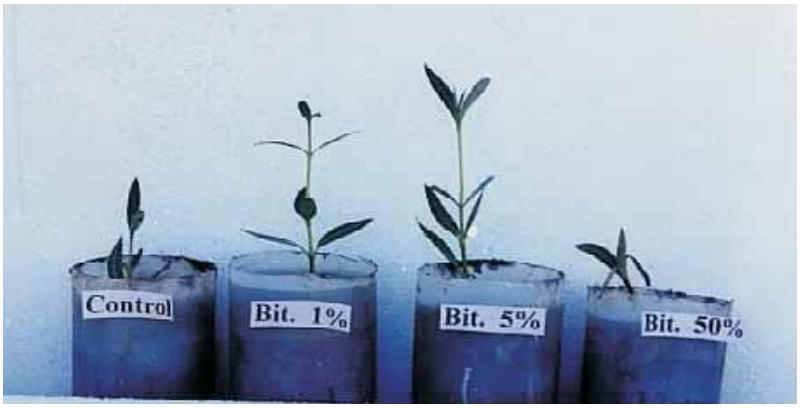
**Coastal Ocean Monitoring and Prediction System (COMAPS):** The Institute continued to monitor the coastal waters of Gujarat under the COMAPS project. The dissolved oxygen, BOD and pH varied in a normal range at most of the transects and stations although localised stress conditions were apparent at some transects. Kandla exhibited highest values of salinity while dissolved oxygen was highest at Okha. Poshitra exhibited highest value of chlorophyll-a and least concentration of ammonia. Dwarka recorded highest value of BOD and highest phytoplankton generic diversity. Porbandar exhibited highest values of $NO_3$, $NO_2$, $NH_4$, Total Nitrogen and Total Phosphorous, possibly due to effluent discharge. This transect also exhibited the highest count of phytoplankton. A disturbing trend was the high stress conditions observed for most of the parameters at Alang.

**Observation of Imposex in Indian Waters:** Anti-fouling marine paints consist of biocides such as tributyl tin that are known to cause imposex. Imposex is the development of penis in females which prevents release of eggs, leading initially to infertility and subsequently to death. This phenomenon has been observed for the first time in Indian waters through studies conducted by the Institute on different species of neogastropods such as Thais bufo (fig.1) and Ocenebra bombayana occurring in Saurashtra coast. The percentage of total population within each species that had developed imposex was found to be in the range of 9-10 % for Thais bufo and Ocenebra bombayana. Studies are continuing to establish conclusively that the observed imposex is indeed due to tributyl tin.

**Effect of Bittern on Mangroves:** The effect of 28.5° Be' bittern was studied on the juvenile plants of Avicennia marina. The elongation growth, percentage increase in number of leaves, and dry weight of the plant were the highest when bittern was added to seawater upto a 5% concentration. This is ascribed to the high concentration of potash in the bittern. However, at 50% concentration of bittern, the growth was inhibitory while 100% concentration was lethal when subjected to continuous exposure for 10 days (see figure below). These results indicate that bittern discharged into the sea can be put to good use to raise mangrove seedlings if the right level of dilution of bittern with seawater can be ensured.

Imposex in Thais bufo: Ia- Normal female; Ib- Imposex; Ic- Normal male

**Environmental Audit:** The Institute continued to undertake environment audits of a number of well known companies in Gujarat including: Tata Chemicals Ltd.; Mithapur, Indian Rayon & Industries Ltd.; Veraval, National Thermal Power Station; Jhanor, Indo-Gulf Corporation Ltd., Dahej, Gujarat Ambuja Cement Ltd., Kodinar; Narmada Cement Company; Jafarabad, and GEB Thermal Power Station, Ukai Dam. The main aim of the audit is to provide suitable recommendations to the industry for waste minimization, better raw material and energy utilization, and prevention of pollution.




Effect of different concentrations of bittern on the growth of Avicennia marina

CSMCRI

Biennial Report: 2000-2002

4

# TECHNOLOGY TRANSFER & INFRASTRUCTURE SERVICES

## Patents filed

### 2000-2001

1. A method for the manufacture of alkali iodates from iodides using an ion-exchange membrane flow reactor. P.K. Ghosh, G. Ramachandraiah, V.R.K.S.Susarala, S.S. Vaghela and A.D. Jethava. Indian Patent Filed: 1057/DEL/2000

2. A process for the preparation of improved organophilic clay useful as gallants for making viscous organic systems. S.D. Gomkale, R.V. Jasra, A.S. Mehta, B.J. Bhalala, D.B. Shukla and R.S. Somani. Indian Patent Filed: 572/DEL/2000

3. An improved process for the preparation of ammonia. R. Prakash, V.K. Shahi, P. Ray, G. Ramachandraiah and R. Rangarajan. Indian Patent Filed: 042/DEL/2001

4. An improved process for cultivation of algae. C.R.K. Reddy, O.P. Mairh, P.V. Subba Rao, G.R. Krishna Kumar, E.Eshwaran, K.H. Mody, and P.K.Ghosh. Patent Filed : US Patent Application No. 09/656,561 and PCT Patent Application No. PCT/ IN/00/00084

5. An improved process for the preparation of hydrotalcite having antacid properties. P.M. Oza, S.H. Mehta, M.R. Gandhi, M.V. Sheth, J.R. Chunawala, and S.D. Gomkale. Indian Patent Field : 1053/DEL/2000

6. A process for the preparation of novel chiral SALEN transition metal catalyst useful in enantioselective epoxidation of pro-chiral olefin. R.I. Kureshy, N.H. Khan, S.H.R. Abdi, S.T. Patel, P.K. Iyer, and R.V. Jasra. Indian Patent Filed: 1160/DEL/2000

7. An improved process for the preparation of chiral epoxides useful as intermediates in the synthesis of chiral drugs. R.I. Kureshy, N.H. Khan, S.H.R. Abdi, S.T. Patel, P.K. Iyer, and R.V. Jasra. Indian Patent Filed: 1161/DEL/2000

8. An eco-friendly method of preparation of high purity Tetrabromo bisphenol-A. G. Ramachandraiah, P.K. Ghosh, A.S. Mehta, R.P. Pandya, A.D. Jethava, S.S. Vaghela, and S.N. Mishra. US patent granted 6, 365, 786 and PCT Patent Application No. PCT/IN01/00009

9. An improved process for the removal of calcium ions from the brine by marine Cyanobacteria. S. Mishra, P.K. Ghosh, M.R. Gandhi, A.M. Bhatt, and S.A. Chauhan. Patent Filed : US Patent Application. No. 09/777,664

10. An improved process for the preparation of phosphonomethyl glysine. R. Rangarajan, S.K. Thampy, B.S.Makwana and D.K.Gohil (with IICT scientists). Indian Patent Filed: 565/DEL/2000.

### 2001-2002

1. A process for preparation of bromine. A.Hussain, S.D.Gomkale, R.S. Shukla, H.J. Padhiyar, R.B.Thorat, and A.S. Mehta. Indian Patent Filed : 1201/DEL/2001.

2. A process for the preparation of formic acid by catalysed hydration of carbon monoxide. R.S. Shukla, A. Hussain, R.V. Thorat, S.D. Bhatt, R.V. Jasra, and H.J.

Padhiyar. Indian Patent Filed :1205/DEL/2001 .

3. A process for desalting of amino acids solutions by means of electrodialysis with conducting spacers. V.K. Shahi, S.K. Thampy, B.S. Makwana, D.K. Gohil, C.R.K. Reddy, R.Rangarajan and P.K. Ghosh. Indian Patent Filed: 0385/DEL/2002.

4. A process for recovery of common salt and marine chemicals from brine in integrated manner. R.N. Vohra, P.K. Ghosh, V.P. Mohandas, H.L. Joshi, H.H. Deraiya, R.H. Dave, K. Halder, R.B. Yadav, S.L. Daga, K.M. Majeethia, and U.P. Saraiya. Patent Filed: US Patent Application No. 10/003,213 and PCT Patent Application No. PCT/IN 01/00185.

5. A process for the generation of finely divided $CaCO_3$ from $CaCO_3$ rich industrial byproduct. R.V. Jasra, P.M. Oza, R.S. Somani, J.R. Chunawala, M.V. Sheth, V.V. Thakkar, and Y.M. Badheka. Patent Filed : US Patent Application No. 09/999,480 and PCT Patent Application No. PCT/INO1/00197

6. Preparation of non-hazardous brominating reagent. S. Adimurthy, A.D. Jethava, S.S. Vaghela, G. Ramachandraiah, A.S. Mehta, and P.K. Ghosh. Patent Filed : PCT Patent Application No. PCT/INO2/ 00386.

7. A process for recovery of Low Sodium Salt from bittern. R.N. Vohra, P.K. Ghosh, M.R. Gandhi, H.L. Joshi, H.H. Deraiya, R.H. Dave, K.M. Majeethia, S.L. Daga, V.P. Mohandas, and R.J. Sanghavi. Patent Filed : US Patent Application No. 10/062,583 ; PCT Patent Application No. PCT/INO2/00018 and Indian Patent Application No. 0067/DEL/2002

8. A process for the preparation of a molecular sieve adsorbent for selectively adsorbing nitrogen and argon from a gaseous mixture with oxygen. J. Sebastian, and R.V. Jasra. Patent Filed: US Patent Application No. 10/105,876

9. Preparation of nutrient rich salt of plant origin. P.K.Ghosh, M.P.Reddy, J.B. Pandya, J.S.Patolia, S.M.Vaghela, M.R.Gandhi, R.J.Sanghavi, V.G.Shravan Kumar, and M.T. Shah. Patent Filed : US Patent Application No.10/106,334 .

10. Electrodialysis Ultrafiltration hybrid process for desalting and dewatering of iron dextran solution. V.K. Shahi, G.S. Trivedi, S.K. Thampy, R. Rangarajan, and P.K. Ghosh. Patent Filed : US and PCT Patent Application.

11. A process for the generation of precipitated calcium carbonate from $CaCO_3$ rich industrial by-product; R.V. Jasra, P.M. Oza, R.S. Somani, J.R. Chunawala, M.V. Sheth, V.V. Thakkar, and Y.M. Badheka. Patent Filed : US Patent Application No. 09/998,968 and PCT Patent Application No. PCT/INO1/00196

# EXTERNAL CASH FLOW (2000-01)

## A. GRANT-IN-AID PROJECTS

| Sr. No | Title of Project | Name of Party/ Funding Agency | Amount Received (Rs.) |
|---|---|---|---|
| 1 | Studies on halophytes and their improvement. | GSFC Science Foundation, Vadodara. | 22,80,450 |
| 2 | Olefin hydroformylation (Integrated Long Term Programme – ILTP). | Dept. of Science & Technology, N. Delhi. | 13,20,000 |
| 3 | Integrated programme for scaled -up cultivation of and processing of phycocolloid seaweeds (Eucheuma). | a) Dept of Biotechnology, New Delhi<br>b)Pepsico India Holdings Ltd, Gurgaon | 14,60,000<br>5,00,000 |
| 4 | Synthesis, characterization and utilisation of chiral metal complexes as active catalyst for enantioselective epoxidation of prochiral alkenes. | Dept. of Science & Technology, N Delhi. | 2,50,000 |
| 5 | Model Bio-village project at Mocha Gorser | Dept of Biotechnology, New Delhi | 6,89,000 |
| 6 | Synthesis, characterization and physico -chemical studies of new redox active mono and binuclear complexes with donor acceptor properties. | Dept. of Science & Technology, New Delhi. | 1,00,000 |
| 7 | Pilot R.O. plant of 2000 lits. per hour capacity for treatment of brackish/ hard ground water at Rajasthan & Gujarat. | Dept. of Science & Technology, New Delhi. | 30,00,000 |
| 8 | Development of solid polymer electrodes reactors using indigenous ion-exchange membranes. | Dept. of Science & Technology, New Delhi. | 2,00,000 |
| 9 | De-arsenification of drinking water from traces of arsenic left over from ion-exchange resins. | Dept. of Science & Technology, New Delhi. | 2,00,000 |
| 10 | Development of durable membranes for the efficient separation of hexane from oil. | Technology Mission on Oils & Pulses (TMOP), New Delhi | 5,34,000 |
| 11 | Monitoring marine pollution under COMAPS programme. | Dept. of Ocean Development, New Delhi | 20,32,000 |
| 1 | Designing ligands fo r selective extraction of potassium ion from bittern. | Dept. of Science & Technology, N . Delhi. | 3,00,000 |
| 2 | Studies on transition metal catalyzed reactions of diazoketones. | Dept. of Science & Technology, N . Delhi. | 99,314 |
| 3 | Nano-material catalysts and asso ciated process technology for alkylation/ acylation reactions, pre - reforming of hydrocarbons and sulphur removal from petroleum fuels. | CSIR, New Delhi | 13,75,000 |
| | | Total | 1,43,39,764 |

## B. COLLABORATIVE PROJECTS

| | | | |
|---|---|---|---|
| 1 | Feasibility studies on Palladium recovery fro m Silica Gel waste. | Strides Arcolab Ltd., Bangalore | 70,000 |
| 2 | Extraction of phycocyanin from spirulina. | Strides Arcolab Ltd., Bangalore | 500,000 |
| 3 | Salt crystallisation and habit modification. | Hindustan Lever Ltd., Mumbai | 520,000 |
| 4 | Commercialization of indigenous R.O. technology. | Centre for High Technology, New Delhi | 600,000 |
| 5 | Indigenisation of R.O. Membrane Technology. | Chennai Petroleum Corporation Ltd., Chennai | 750,000 |
| 6 | Up-gradation of Calcium carbonate | Gujarat Narmada Valley Fertilizers Co. Ltd., Narmadanagar. | 700,000 |
| | | Total | 31,40,000 |

## C. SPONSORED RESEARCH PROEJCTS

| | | | |
|---|---|---|---|
| 1. | Development of viable technology for Hypnea cultivation, harvesting and manufacture of semi - refined Kappa Carrageenan (SRC) there from. | M/s. Pepsico India Holdings Ltd., Gurgaon. | 7,16,000 |
| 2. | Preliminary work related with Glass Epoxy laminate. | GNFCL, Narmadanagar. | 35,000 |
| | | Total | 7,51,000 |

## D. CONSULTANCY PROJECTS

| | | | |
|---|---|---|---|
| 1 | Environmental audit | Tata Chemicals Ltd., Mithapur. | 2,20,000 |
| 2 | Process know -how and technical support for setting up a salt washery at Sambhar Salts Ltd. | Promantac Consultants Pvt. Ltd., Vadodara. | 75,000 |
| 3 | Environmental audit of a unit of M/s. Indian Rayon Ind. Ltd., Veraval. | Indian Rayon and Industries Ltd., Veraval. | 2,75,000 |
| 4 | Development of a salt work | Gram Technology Sans - tha Gujarat, Gandhinagar | 47,000 |
| 5 | Evaluate the quality of effluent from existing bromine plant and to suggest plan for disposal of solid waste and liquid effluent. | BILT Chemicals Ltd., Bhuj | 25,000 |
| 1 | Environmental audit. | M/s. Indo Gulf Corporation Ltd., Dahej. | 2,90,000 |
| 2 | Environmental Audit. | National Thermal Power Corpn. Ltd., Jhanor, | 3,60,000 |
| 3 | Environmental Impact Studies on the effect of soda ash industry effluent. | Saurashtra Chemicals Ltd., Birlasagar | 4,12,500 |
| | | Total | 17,04,500 |

## E. TECHNICAL ASSISTANCE

| | | | |
|---|---|---|---|
| E.1: Exploratory Works/ Technical Assistance | | | |
| 1 | Supply of solar still design | Dhammjyoti Kamble, Washim (M.S.). | 150 |
| 2 | To explore possibility of developing a process to treat the effluent from clay activation. | Ashapura Volclay Ltd., Bhuj | 50,000 |
| 3 | To test sam ples received from party on Bench Scale Washery. | Indo Salt Company, Delhi. | 25,000 |
| 4 | Specific analytical job- Structural elucidation. | Biddle Interme4diates Pvt. Ltd., Ahmedabad. | 3,780 |
| 5 | Visit of a scientist- find out possibilities of growing grasses in saline soil. | Ashapura Volclay Ltd., Bhuj | 9,000 |
| 6 | Exploratory work - To explore possibility to prepare Free Flow Salt from Rock Salt. | Marine Mineral & Herbal Remedies P Ltd., Jaipur. | 75,000 |
| | | Total 5A | 1,62,930 |
| E.2: Training Programmes | | | |
| | Training programme fo r Agarias arranged by Govt. of Gujarat. | Gram Technology Institute, Gandhinagar. | 40,000 |
| E.3: Sale of Lab. Products | | | 1,07,075 |
| | Total of Technical Assistance E[1+2+3] | | 3,10,005 |

## F. TECHNOLOGY TRANSFER: ROYALTY/PREMIA

| | | | |
|---|---|---|---|
| 1 | Liquid Seaweed Fertilizer. | A.F.E. Industries, Nasik. | 2,75,000 |
| 2 | Eucheuma Cultivation | Pepsico India Holdings Ltd., Gurgaon | 7,50,000 |
| | Total | | 10,25,000 |

## G. ANALYTICAL/ TESTING CHARGES:

| | |
|---|---|
| Total 134 assignments | 4,26,966 |

## ECF 2000-01: AT A GLANCE

| Type of Projects | Amount (Rs.) |
|---|---|
| A. Grant in-aid projects | 1,43,39,764 |
| B. Collaborative projects | 31,40,000 |
| C. Sponsored Research projects | 7,51,000 |
| D. Consultancy assignments | 17,04,500 |
| E. Technical Assistance | 3,10,005 |
| F. Technology Transfer (Royalty/Premium) | 10,25,000 |
| G. Analytical/Testing Charges | 4,26,966 |
| Grand Total | 2,17,22,235 |

# ECF GENERATED DURING 2001-2002

## A. GRANT-IN-AID PROJECTS

| Sr. No. | Title of Project | Funding Agency | Amount (Rs.) |
|---|---|---|---|
| 1. | NMDC on marine chemicals and algal resources | INCOIS (DOD), Hyderabad | 500,000 |
| 2. | Study of the changes in sulphated polysaccharide contents of seaweeds as a function of life stages and season | Dept. of Biotechnology, New Delhi | 591,000 |
| 3. | Collection, identification and chemical investigation of marine flora | Dept. of Ocean Development, New Delhi | 1,699,000 |
| 4. | Adsorbents for separation of oxygen/ nitrogen/ argon | Dept. of Science & Technology, New Delhi | 250,000 |
| 5. | Defluoridation of the ground water in Gujarat and Saurashtra region by ion-selective resins | Ministry of Rural Development, RGWDWM, New Delhi | 410,400 |
| 5. | Fundamental studies on nucleation and crystal growth of zeolites and hydrotalcite | Dept. of Science & Technology, New Delhi | 268,800 |
| 6. | Studies on Halophytes and their improvements | GSFC Science Foundation, Vadodara | 699,204 |
| 7. | Synthesis, characterization and utilisation of chiral metal complexes as active catalysts for ananioselective epoxidation as prochiral alkenes | Dept. of Science & Technology, New Delhi | 175,000 |
| 8. | Conservation & propagation of Agar yielding sea weeds (Gelidiella, Gelidium and Gracilaria) of Gulf of Mannar marine bio-reserve | Ministry of Environment & Forests, GOI, New Delhi | 120,000 |
| 9. | Synthesis, Characterization and physico-chemical studies of new redox active mono & binuclear complexes with donor acceptor properties. | Dept. of Science & Technology, New Delhi | 85,384 |
| 10. | Digitised Inventory of Marine Bio-resources Seaweeds | Cochin Univ. of Sci. & Tech., Kochi (Dept. of Bio-technology through DOD) | 95,500 |
| 11. | Integrated programme for scaled up cultivation & processing | Dept. of Biotechnology, New Delhi | 1,891,000 |
| 12. | Side chain alkylation of toluene with methanol over novel solid base catalysts | INSA, New Delhi | 99,024 |
| 13. | Biodegradable functional polyesters & their membranes for bio-medical applications | Dept. of Science & Technology, New Delhi | 240,000 |
| 14. | Studies on the role of bridging and non bonding interactions in tuning metal–metal interaction in bi and poly-nuclear metal complexes | Dept. of Science & Technology, New Delhi | 600,000 |
| 15. | Development of enantioselective catalysts for synthesis of drug intermediate based on chiral binol and binapmetal complexes supported on inorganic porous solids | Dept. of Science & Technology, New Delhi | 380,000 |
| | | | 8,104,312 |

## B. COLLABORATIVE PROJECTS

| Sr. No. | Title of Project | Funding Agency | Amount (Rs.) |
|---|---|---|---|
| 1 | Indian Reference Material | NPL, New Delhi | 80,000 |
| 2 | Feasibility studies on Palladium recovery from silica gel waste | Strides Arcolab Ltd., Bangalore | 664,500 |
| 3 | Extraction of phycocyanin from Spirulina | Strides Arcolab Ltd., Bangalore | 250,000 |
| 4 | Commercialisation of Indigenous RO technology | Centre for High Technology (CHT), New Delhi | 3,009,857 |
| 5 | Feasibility studies on the conversion of strides effluents to Zeolite A | Strides Arco Lab, Bangalore | 50,000 |
| | | | 4,054,357 |

## C. SPONSORED RESEARCH PROEJCTS

| Sr. No. | Title of Project | Funding Agency | Amount (Rs.) |
|---|---|---|---|
| 1 | Development of viable technology for Hypnea cultivation, harvesting and manufacture of semi-refined Kappa carrageenan (SRC) there from | Pepsico India Holdings Pvt. Ltd., Gurgaon | 1,050,000 |
| 2 | Pilot plant studies for treatment of brackish water by Reverse Osmosis technique | Shrujan Hasta-Shilp, Bhuj-Kutch | 80,000 |
| 3 | Pilot plant studies for treatment of brackish water by RO technique | Shree Vivekanand Research & Training Institute, Kutch, Gujarat | 255,000 |
| | | | 1,385,000 |

## D. CONSULTANCY PROJECTS

| Sr. No. | Title of Project | Funding Agency | Amount (Rs.) |
|---|---|---|---|
| 1 | Environmental audit | Tata Chemicals Ltd., Mithapur | 305,000 |
| 2 | Evaluation of quality effluent | BILT Chemicals Ltd., Bhuj | 25,000 |
| 3 | Environmental audit | Gujarat Ambuja Cements Ltd., Ambujanagar | 251,098 |
| 4 | Technical feasibility and economic viability report for salt refinery | Hindustan Salts Ltd., Jaipur | 100,000 |
| 5. | Environmental Audit | GEB, Thermal Power Station, Ukaidam-394680 | 130,000 |
| 6. | Environmental audit | Indo Gulf Corpn., Bharuch | 290,000 |
| 7. | Environmental audit | NTPC, Bharuch, (Jhanor) | 200,000 |
| 8. | Environmental audit | Saurashtra Chemicals Ltd, Porbander | 412,500 |
| | | | **2,523,598** |
| | | **TOTAL (A-D):** | **17,417,267** |

## E. TECHNICAL ASSISTANCE

| | | | |
|---|---|---|---|
| E1. Exploratory work | | | |
| | Exploratory work on waste water treatment | Narmada Chemature PetroChemicals Limited, Narmada Nagar | 10,000 |
| **E.2 Sale of Lab. Products** | | | |
| 1 | 50L of customer prepared co-polymeric adsorbent | CFTRI, Mysore | 50,000 |
| 2 | Sale of dried Eucheuma Cottonii material received from Mandapam camp | Pepsico India Holdings Pvt. Ltd., Gurguon | 30,000 |
| 3 | Supply of Cyanobacteria cultures | Nu Tech Farm, Innovative organic Farming, Mumbai | 500 |
| 4 | Supply of Iodine Estimation Kit for Iodised salt | UNICEF, New Delhi | 700,000 |
| 5 | Herbal Extractor (Membrane based) | RRL, Bhopal | 75,000 |
| | | **TOTAL** | **855,500** |
| F. ROYALTY/PREMIA | | | 1,610,000 |
| G. TESTING AND ANALYSIS | | | 855,500 |

## ECF 2001-02 - AT A GLANCE



| | | Rupees |
|---|---|---|
| A. | Grant-in-Aid projects | 8,104,312 |
| B. | Collaborative projects | 4,054,357 |
| C. | Sponsored Resear ch projects | 1,385,000 |
| D. | Consultancy projects | 2,523,598 |
| E. | Technical Assistance | 865,500 |
| F. | Royalty/ Premia | 1,610,000 |
| G. | Testing & Analysis | 286,265 |
| | Total | 18,829,032 |

The CSMCRI library is considered to be a premier one in this region having a rich collection of books, periodicals, reference materials, etc in the areas of R&D being carried out in the Institute. Besides catering to the information need of R&D staff of the institute, the Library also extends facilities to the visiting research scholars, university staff, and representatives of the industries, government officials and others. A brief account of library collection, facilities, services are as under.

Journals subscribed: 2000-01 2001-02

| Sr. No. | Document type | Available as on 1st April , 2000 | Add ition during 2000-01 | Total as on 31st March, 2001 | Addition during 2001-02 | Total as on 31st, March 2002 |
|---|---|---|---|---|---|---|
| 1 | Books | 11290 | 243 | 11533 | 104 | 11637 |
| 2 | Back volumes | 23800 | 752 | 24552 | 26 | 24578 |
| 3 | Translation | 426 | 1 | 427 | 2 | 429 |
| 4 | Photocopy | 1964 | 5 | 1969 | 115 | 2084 |
| 5 | Patent | 323 | 6 | 329 | 4 | 333 |
| 6 | Standards | 750 | 2 | 752 | 9 | 761 |
| 7 | Microcards | 67 | 0 | 67 | 0 | 67 |
| 8 | Microfilm | 1326 | 0 | 1326 | 0 | 1326 |
| 9 | Maps/charts | 265 | 0 | 265 | 0 | 265 |
| 10 | Reprints | 2692 | 0 | 2692 | 0 | 2692 |
| 11 | Annual reports | 8172 | 67 | 8239 | 99 | 8338 |
| 12 | CD-Rom | 4 | 6 | 10 | 4 | 14 |
| | Total | 51079 | 1015 | 52094 | 262 | 53019 |

| | | |
|---|---|---|
| Foreign Journals | 80 | 84 |
| Indian journals | 119 | 119 |
| Journals received in gratis/ exchange | 50 | 60 |

### Information services:

For easy and quick access to current and latest information by the R&D staff, library renders various information services to its readers. Through these services, scientific and technical staff is kept well informed about the current trends in the field of their interest. The services rendered are as follows:

- Inter-library loan service
- Reader queries

- Reprint and photocopy mailing
- Bibliographies on selected areas using current content and chemical abstracts
- Reference services.
- Literature search facility to outsider.

The library is having specialized up-to-date collection of international abstracting services viz. Chemical Abstracts, Biological Abstracts, Current Content; back volumes of journals in chemistry, chemical technology, biological sciences; CD's of Ulaamann's Encyclopedia, Chemistry Comes Alive, Young Scientist, World Book Encyclopedia etc. The outsiders are also granted permission to consult the documents in the library. This fulfills the aim of maximum utilization of library documents.

During the period under report library has granted permission to outsiders as follows:

| | 2000-01 | 2001-02 |
|---|---|---|
| Long term permission | 10 | 20 |
| Short term permission | 20 | 22 |
| Corporate members | 6 | 8 |
| Outsiders who consulted the library | 381 | 468 |

## DATELINE

April 10, 2000

CSMCRI Foundation Day celebrated. Dr. R.A. Mashelkar, Director General, CSIR delivered the Foundation Day Lecture. He stressed on the “Power of Knowledge” and strongly advocated the need for IPR. A meeting of the Customers of CSMCRI with the DG was also organised as a part of the celebration. Dr. Mashelkar also discussed business opportunity and related issues with the participants.

September 12-13, 2000

The National symposium on the seaweeds of India: Biodiversity and Biotechnology. Ninety nine delegates attended the symposium. The symposium was conducted in eight technical sessions. Ten keynote addresses were delivered and eighty-five research papers were presented and deliberated upon.

September 26, 2000

CSIR Foundation Day celebrated. Shri R.J. Shah, Chief Industrial Advisor, Govt. of Gujarat delivered the Foundation Day Lecture 'Technology Management Perspectives of the State Government”

Staff members who completed of 25 years of service were felicitated with presentation of mementoes on the occasion. Members of staff who superannuated during the previous twelve months were also honoured with

presentation of mementoes. School going children of the employees of the Institute who secured top positions in the Essay competition organised on this occasion were also awarded prizes during the Foundation Day Function. Awards for special achievements in Board examinations were also presented.

The Institute was kept open to visitors. The scientists with the help of visual displays and models explained the R&D activities of the Institute.

October 19- 20, 2000

CSIR Programme on Youth for Leadership in Science (CPYLS) organised. Sixty students along with their parents participated.

November 14-27, 2000

CSMCRI participated in IITF at Technology Exports Pavilion, New Delhi

January 5-9, 2001

Participated in 'Udyog Darshan" exhibition at Gujarat University held under the auspices of Industries Commissioner, Gujarat

January 14-28, 2001

Participated in "Vigyan Darshan" exhibition at Allahabad and effectively demonstrated desalination technology by providing safe drinking water to the pilgrims visiting the 'Kumbha Mela"

April 10, 2001

47th CSMCRI Foundation Day. The Chief Guest Prof. J B Joshi, Director, UDCT, Mumbai gave address on "Academic as a Consultant to Industry"

September 26, 2001

CSIR Foundation Day celebrated. The Chief Guest of the occasion Dr V. V. Subba Rao, Principal Scientific Advisor, ICICI Knowledge Park, Hyderabad gave a presentation on "Business Driven Research: Challenges & Opportunities".

Members of staff who completed 25 years of service were felicitated with mementoes on the occasion. Those staff members who superannuated during the previous twelve months were also honoured with presentation of mementoes. Essay competition was organized for school going children of the employees of the Institute on this occasion and those who secured top positions were awarded prizes during the Foundation Day Function. Awards for special achievements in Board examinations were also presented.

The Institute observed Open Day, and the scientists with the help of visual displays and models explained the R&D activities of the Institute to the visitors.

November 1-2, 2001

CSIR Programme for Youth for Leadership in Science (CPYLS) organised. Various programme viz. quiz & elocution competitions, cultural programme

(mono-acting, drama, songs) were arranged.

## DEPUTATION/VISIT OF FOREIGN SCIENTIST TO CSMCRI

### 2000-01

1. Prof. Dr. Klaus Becker, University of Hohenheim, Stuttgart, Germany, visited CSMCRI from April 17, 2000 to May 1, 2002, under CSIR-DAAD Exchange of Scientists programme. His visit was for interactive discussion on cultivation of Jatropha and related aspects.
2. Dr. TaeHwanKim, Scientist, Korean Institute of Energy Research (KIER), visited CSMCRI from May 19-31, 2000 under an agreement for technical cooperation between KIER and CSMCRI. The visit was for discussing ongoing and future R&D collaboration in adsorption and catalysis.
3. Dr. SangSupHan of the Korean Institute of Energy Research (KIER), visited CSMCRI during November 23-24, 2000 for first hand information on the Institute's work on adsorption. The visit was under an agreement for technical cooperation between KIER and CSMCRI.
4. Prof. Dr. J. Richter and Prof. Dr. M. Zeidler, RWTH, Institut Für Physikalische Chemie, Aachen, Germany visited CSMCRI during March 1-4, 2001 under DAAD-DFG (Deutsche Forschung Gesselshaft) programme for discussion “Digital image holography in molten salts of ionic liquids.

### 2001-02

1. Dr. Ramsharan Singh, Scientist, The Ohio State University, Columbus, USA, visited CSMCRI March 18-22, 2002 to discuss in details the progress of DST-NSF Joint Collaborative project on “Fundamental studies of nucleation and crystal growth of zeolites and hydrotalcite”.

## DEPUTATION/VISIT ABROAD OF CSMCRI SCIENTIST

### 2000-01

1. Mr. M.R. Gandhi, Scientist attend the 8th World Salt Symposium in the Netherlands from 7th to 11th May, 2000 to and presented a paper entitled “Byproduct salt recovery from solid industrial effluent of hydrazine manufacturing plant”.
2. Dr. Parimal Paul, Scientist visited USA from 15th November, 1999 to 14th December, 2000 on Sabbatical leave to carry out research work on synthesis and reactivities of designed inorganic/ organometallic compounds at the University of California.
3. Dr. Amjad Hussain, Scientist visited Canada on Sabbatical leave from 18th February, 2000 to 23rd January, 2001 for pursuing research work on synthesis of organometallic compounds and their use in catalysis at the University of Alberta.

### 2001-02

1. Dr. N.H. Khan, Scientist visited South Korea from 5th October, 2000 to 24th September, 2001under Sabbatical leave. During this period he

carried out research work at the Department of Chemistry, Inha University, Inchon, on the development of radio-labeled compounds through catalytic route and designing of new ligands, their metal complex synthesis for use as catalysts in biological systems.

2. Dr. Amitava Das, Scientist was deputed to the USA from 1st May to 31st October, 2001under a Raman Research Fellowship to carry out R&D work on design of Zeolite based artificial photosynthetic assemblies at the Ohio State University, Columbus, USA.
3. Dr. G. Ramachandraiah, Scientist visited Germany from 1st October to 31st December, 2001 to carry out research work at the Institut Für Anorganische Chemie, der Universitat Erlangen. His research interest was to develop newer water soluble or insoluble compounds to reduce NN bonds by newer electrochemical methods.
4. Dr. S. Muthusamy, Scientist visited UK under Bilateral Exchange Programme of INSA for three months with effect from 1st October, 2001 to carry out research work with Prof. C.J. Moody, University of Exeter, on the development of novel chiral dirhodium (II) catalysts.
5. Dr. S.K. Thampy, Scientist visited China from 18th November to 2nd December, 2001 under the Bilateral Exchange Programme of INSA with the Chinese Academy of Sciences (CAC). During his stay in at the Zhejiang University, Hangzhou, he acquired knowledge of various applications of ion-exchange and on aspects like increasing the life of membranes and means to avoid polarization during electrodialysis.
6. Dr. P.K. Ghosh, Director, visited Germany from 20th to 24th November, 2001 to participate in the Second Environment Forum Magdeburg organized by the UNEP and DaimlerChrysler AG Germany. He also made a presentation on “Biofuels from eroded soils in India A concept for sustainable transport”.
7. Dr. R.V. Jasra, Scientist visited the Ohio State University, Columbus, USA from 28th November to 12th December, 2001 under DST-NSF collaborative work. The visit was taken up to define the experiments to be carried out at both the participating laboratories.
8. Dr. S. Kannan, Scientist, on being awarded the Alexander von Humboldt Research Fellowship, visited Germany for a period of one year from 1st June, 2001. During the tenure of the fellowship he carried out research work on “Hydrotalcite-like compounds and their modified forms characterization and their structure-activity relationships” at the Universitat Munchen.

CSMCRI

Biennial Report: 2000-2002

# ANNEXURE

## PAPERS PUBLISHED
2000-01

1. Relative viscosity and surface tension of subsoil brines: A case study of Chandan subsoil brine; V. R. K. S. Susarla and R. A. Buch, J. of Indian Chemical Society, 2000, 297.

2. Correlation between spectroscopic, electrochemical, and kinetic properties of cyno-bridge binuclear complexes: Analysis of temperature, pressure and solvent effects; D. E. Khoshtariya, H. C. Bajaj, P. A. Treglon and R. van Eldik, J.Phys.Chem., 2000, 104, 5535.

3. Metal assisted unusual hydroxylation at the carbon atom of the triazine ring in dinuclear ruthenium(II) and osmium (II) complexes bridged by 2,4,6-tris(2-pyridyl)-1,3,5-triazine: synthesis, structural characterization, stereochemistry and electrochemical studies; P. Paul, B. Tyagi, A. K. Bilakhia, P. Dastidar and E. Suresh, Inorg. Chem., 2000, 39, 14.

4. Solid state ion exchange in zeolite bodies; N. V. Choudary, S. G. T. Bhatt and R. V. Jasra; Adsorption Science and Technology, Ed. D.D.Do,World Scientific publ. Co., Singapur, 2000.

5. Photooxidation of some Nickel(II) macrocyclic complexes in non aqueous solvents; T. Dhansekaran, P. Paul and P. Natrajan, J. Photochem. Photobio, 2000, 131, 75.

6. The origin of the 'spike' in the EPR spectrum of $C^-_{60}$; P. Paul, R. D. Bolskar, A. M. Clark and C. A. Reed., Chem. Comm, 2000, 1229.

7. Facile synthesis of oxatricyclic systems with various ring sizes and substituents; S. Muthusamy, S. A. Babu, C. Gunanathan, E. Suresh, P. Dastidar and R. V. Jasra. Tetrahedron, 2000, 6307.

8. Dinuclear ruthenium(II) and/or osmium(II) complexes of bipyridyl ligands bridged by riged spacers: synthesis, characterization, electrochemical behaviour and luminescence properties. A. K. Bilakhiya, B. Tyagi, P. Paul, Polyhedron, 2000, 19, 1233.

9. Study on the pyrrol derivative reaction process using maleic anhydride; H. D. Jeong, K. I. Kim, T. H. Kim, S. H. Cho and H. C. Bajaj, Theories and Application of Chemical Engg. (KIChE), 2000, 6, 2445.

10. Novel chemoselective 1,3-dipolar cycloaddition of rhodium generated carbonyl yields with arylidenetetralones; S. Muthusamy, S. A. Babu, C. Gunanathan, Tetrahedron Letters, 2000, 41, 8839.

11. Microwave assisted rapid crystallization of Mg-M(III) hydrotalcite where M(III) = Al,

Fe and Cr; S. Kannan and R. V. Jasra. Journal of Material Chemistry, 2000, 10, 2337.

**12.** Role of bridging ligand in tuning metalmetal interaction in mixed valance complexes; (invited review article); A. Das, A. D. Shukla and H. C. Bajaj; Indian J. Chem., 2000, 77, 51

**13.** Synthesis and single crystal investigation of two dimensional rectangular network [M(4,4-pby)(Phth)($H_2O$)]n.2$H_2O$ with small neutral cavities; E. Suresh, K. Boopalan, R. V. Jasra and M. M. Bhadbhade, Inorg. Chem., 2001, 40, 4078.

**14.** Redox responsive binuclear complexes using 5,6-dihydroxy-1,10-phenanthroline as a bridging ligand : Synthesis, characterization and physicochemical studies; A. D. Shukla and A. Das. Polyhedron, 2000, 19, 2605.

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17. Synthesis of novel oxatetracyclo[6.5.1.$0^{1,6}$.$0^{9,13}$]tetradecene ring systems via carbonyl ylides, S. A. Babu, C. Gunanathan and S. Muthusamy; ibid

18. Equilibrium data on bromine-brine system; A. S. Mehta, Chemical Engineering Congress, CLRI, Chennai, December 19-22, 2001,

19. Studies on chronopotentiometric and electrodialytic properties of amino acids; V. K. Shahi, S. K. Thampy and R. Rangarajan, National Symposium on Chemical Sciences: Advancing Frontiers, CDRI, Lucknow, June 3- 4, 2001.

20. Desalting of low saline water by electrodialysis, P. Ray, G. S. Trivedi, B. G. Shah & S. K. Adhikary, Tenth National conference on Surfactants, Emulsions and Biocolloids, Shilong, October 3-5, 2001.

21. Studies on surfactant immobilized ion-exchange membranes; V. K. Shahi, S. K. Thampy and R. Rangarajan, International Conference on Progress in Disperse Systems, University of Calcutta, Kolkata, January 16- 18, 2002.

22. Preparation and application of porous ion exchange membrane; P. Ray, B. G. Shah and S. K. Adhikary; ibid

23. Experimental field cultivation of Kappaphycus alverrezii (Doty) Doty on the Southeast coast of India and its carrageenan content; K. Eswaran, C. Periyasamy, K. H. Mody, P. V. Subba Rao and A. Tewari, National Symposium on Marine Algal Research in India, Bharathidasan University, Thiruchirappli, August 16-18 2001.

24. Seasonal variation in biomass, plant morphology and agar of Gelidiella acerosa (Forraskal) Feldman et Hamel from Gulf of Mannar, Southeast coast of India; M. Ganesan, K. Eswaran, S. Vasuki, P. V.Subba Rao and C. R. K.Reddy, ibid

25. Indian carrageenophytes: Resources and possible cultivation; P. V. Subba Rao, K. Eswaran, M. Ganesan, S. Thiruppathi and A. Tewari, ibid

26. Biodiversity of benthic marine algae of the Indian coast; R. M. Oza, S. H. Zaidi, A. Tewari and P. K. Ghosh; ibid

27. Comparison Of Free Amino Acid Content In Cyanobacterial Spp. Under Salinity Stress; R. Pawar, A. Patel, S. Mishra, P. Shukla, A. Tewari, P. K. Ghosh, ibid

28. Microbiological management of industrial effluent; V. Patel, A. Iyer, K H Mody, A Tewari and I L Kothari, VIII National Conference of Women in Science, Strategic Approaches to Protect the Environment, Agharkar Research Institute, Pune, September 12-14, 2001.

29. Production of Micropropagules through tissue culture of Eucheuma; C R K Reddy, G. Rajakrihna Kumar, A. Tewari, BIOTECHCON-2001, Vallabhbhai Patel Chest

Institute, University of Delhi, Delhi, October 4-6, 2001.

30. Alkaline Protease from a marine bacterium: A detergent additive; V. Gohel, K. Mody, A Tewari and I L Kothari. National Conference on "Emerging Areas in Plant Sciences, Department of life sciences, Bhavnagar University, Bhavnagar at Palitana, October 5-6, 2001.

31. Microbiological treatment of industrial effluent: V. Patel, A. Iyer, K. Mody and A. Tewari, ibid.

32. Biosequestering of chromium from tannery effluent by halophilic cyanobacteria; P. Shukla, R. Sanghavi, R. Pawar, A. Patel, S. Mishra and A. Tewari; International Congress of Chemistry and Environment, Place December 16 18, 2001.

## Staff News

### Awards / Recognition

### Appointment, Promotion, Retirement, Transfer, Resignation: 2000-02

Appointments

@ - Transferred on selection from CFRI, Dhanbad; # - Promoted on selection

Promotions (Assessment /DPC etc.)

| Sr. No. | Awards/Recognition | Awardee(s) |
|---|---|---|
| 1. | VASVIK award (Vividhlaxmi Audyogik Samshodhan Vikas Kendra award ) for the year 1998 for his work in the field of Chemical Sciences and Technology. The award cons ists of a certificate, memento and a cash prize of Rs. 25,000. | Mr. M.R. Gandhi, Scientist EII |
| 2. | Dr. Vikram Sarabhai Award for the year 1998-99 in the field of biotechnology, the Government of Gujarat for 'Development of improved varieties of cultivated seaweeds of India through biotechnological intervention' . The award consists of a certificate, memento and cash prize of Rs. 1 lakh. | Dr. C.R.K. Reddy, Scientist EI |
| 3. | CSIR Technology Award for the year 2001 -2002 for "The Development of large scale cultiva tion of Eucheuma and production of κ-Carrageenan there from". Award presented by the Hon 'ble Minister for Human Resource Development and Science & Technology and Vice President CSIR, Shri Murali Manohar Joshi at a function held at N ational Physical Laboratory, New Delhi on 26 September 2001. The award carries a certificate, memento and cash prize of Rs. 2 lakh. | Drs. O P Mairh, K Eswaran, C.R.K Reddy, A S Mehta, K H Mody, P V S Rao, P M Oza, P K Ghosh, & S/Shri J R Chunawala, A Tewari, G Raja Krishna Kumar |
| 4. | Raman Research Fellowship of the CSIR, to carry out R&D work on design of "Zeolite based artificial photosynthetic assemblies" at the Ohio State University, Columbus, USA. | Dr. Amitava Das, Scientist EI |
| 5. | Alexander von Humboldt Research Fellowshi p, Germany to work on a research project entitled "Structure -Activity Relationships of Hydrotalcites - A novel class of Layered Materials" with Prof. Helmut Knozinger of University of Munich, Germany.June 2001 to May 2002 | Dr.S. Kannan, Scientist C |
| 6. | BOYSCAST Fellowship of D ept. of Science & Technology, Govt. of India, tenable in Italy ; Feb. 2002 | Dr. P. S. Subramanian, Scientist C |

Retirement

* Voluntary retirement

Transfer

Obituary

The Director & Staff of the CSMCRI deeply mourn the sad and untimely demise of their colleagues

Shri A. Muniyan, Jr. Security Guard (5th September, 2000),

Smt. J.M. Parmar, Tech Gr. I(1) (23rd February, 2001)

Shri Babu Devji, Safaiwala (26th November, 2001), and
Shri K.K. Chitroda, Jr. Security Guard (11th March, 2002)

# Research Council & Management Council

| Sr. No. | Name | Designation | Date of joini ng |
|---|---|---|---|
| 2000-01 | | | |
| 1 | Shri Mukesh Kumar Yadav | J.T.A- Gr. III910 | 5.4.2000 |
| 2 | Shri S. Adimurthy | Scientist Gr. IV(1) | 3.10.2000 |
| 3 | Shri Kamlesh Prasad | Scientist Gr. IV(1) | 30.10.2000 |
| 4 | Shri Sheikh Bhasa | Scientist Gr. IV(2) | 7.12.2000 |
| 5 | Shri Pallab Ghosh | Scientist Gr. IV(2) | 14.3 2001 |
| 6 | Shri Shobhit Singh Chauhan | Scientist Gr. IV(1) | 10.9.2001 |
| 7 | Shri Rakesh Singh Bisen | Tech. Officer Gr.III (4) | 10.9.2001 |
| 8 | Shri David Livingston[@] | Tech. Officer Gr. III(3) | 14.9.2001 |
| 9 | Shri Vaibhav Mantri | Scientist Gr. IV(1) | 24.9.2001 |
| 10 | Dr. Bishwajit Ganguli | Scientist Gr. IV(2) | 4.10.2001 |
| 11 | Shri S.L. Daga[#] | Scientist Gr. IV(5) | 14.12.2001 |
| 12 | Shri Kulundeivelu | Scientist Gr. IV(1) | 26.12.2001 |
| 13 | Shri R. Sukumaran | Driver | 15.1.2002 |
| 14 | Dr. Bhavnath Jha | Scientist Gr. IV(5) | 18.2.2002 |
| 15 | Shri Ramavtar Meena | Scientist Gr. IV(1) | 11.3.2002 |
| 16 | Shri Krishan Singh | Security Officer | 21.3.2002 |

Research Council (Till 31.12.2000)

Prof. V.Krishnan, Chairman

| Sr. No. | Name | Promoted as | With effect from |
|---|---|---|---|
| 1. | Dr. O.P. Mairh | Scientist – Gr. IV(5) | 1.4.1998 |
| 2. | Dr. S.H. Mehta | Scientist - Gr. IV(4) | 1.2.1998 |
| 3. | Dr. (Ms) S.V. Joshi | Scientist - Gr. IV(4) | 1.2.1998 |
| 4. | Dr. G. Ramachandraiah | Scientist - Gr. IV(4) | 23.12.1997 |
| 5. | Shri V. Balakrishnan | Scientist - Gr. IV(4) | 1.2.1998 |
| 6. | Dr. (Ms) K.H. Mody | Scientist - Gr. IV(4) | 1.2.1998 |
| 7. | Shri K.N. Patel | Scientist - Gr. IV(4) | 4.5.1998 |
| 8. | Dr. R.C. Mody | Scientist - Gr. IV(3) | 1.2.1998 |
| 9. | Dr. A.K. Siddhanta | Scientist - Gr. IV(3) | 14.7.1997 |
| 10. | Shri S.N. Rao | Scientist - Gr. IV(3) | 1.2.1998 |
| 11. | Dr. S.T. Zodape | Scientist - Gr. IV(3) | 1.2.1998 |
| 12. | Dr. V.R.K.S. Susarala | Scientist - Gr. IV(4) | 1.2.1999 |
| 13. | Dr. P.V. Subba Rao | Scientist - Gr. IV(4) | 1.2.1999 |
| 14. | Dr. B.K. Ramavat | Scientist - Gr. IV(3) | 1.4.1998 |
| 15. | Dr. A.U. Hamidani | Scientist – Gr. IV(2) | 3.2.1998 |
| 16. | Dr. N.H. Khan | Scientist – Gr. IV(2) | 16.9.1997 |
| 17. | Dr. Amitava Das | Scientist – Gr. IV(3) | 1.9.1998 |
| 18. | Dr. P.S. Subramanian | Scientist – Gr. IV(2) | 12.4.1998 |
| 19. | Dr. K.M. Popat | Scientist – Gr. IV(2) | 1.2.1999 |
| 20. | Dr. G.S. Trivedi | Scientist – Gr. IV(2) | 1.2.1999 |
| 21. | Dr. K. Eshwaran | Scientist – Gr. IV(2) | 16.2.1999 |
| 22. | Shri J.R. Chunawala | Scientist – Gr. IV(2) | 27.12.1998 |
| 23. | Dr. M.M. Bhadbhade | Scientist – Gr. IV(4) | 5.10.1997 |
| 24. | Dr. N.N. Rao | Scientist – Gr. IV(3) | 19.5.1997 |
| 25. | Dr. S.B. Halligudi | Scientist – Gr. IV(3) | 5.5.1998 |

| | | | |
|---|---|---|---|
| 26. | Dr. D.B. Shukla | Scientist – Gr. IV(4) | 1.2.2000 |
| 27. | Dr. Parimal Paul | Scientist – Gr. IV(4) | 1.6.2000 |
| 28. | Shri A.M. Shah | Scientist – Gr. IV(4) | 1.2.2000 |
| 29. | Dr. S.K. Adhikary | Scientist – Gr. IV(4) | 1.2.2000 |
| 30. | Dr. M.P.Reddy | Scientist – Gr. IV(4) | 24.4.2000 |
| 31. | Dr. J. Chikara | Scientist – Gr. IV(4) | 26.5.2000 |
| 32. | Shri V.J. Shah | Scientist – Gr. IV(6) | 8.4.1997 |
| 33. | Shri A. Tiwari | Scientist – Gr. IV(6) | 30.11.2000 |
| 34. | Shri S.N. Ghosh | Scientist – Gr. IV(5) | 1.4.1999 |
| 35. | Dr. P.M. Oza | Scientist – Gr. IV(5) | 24.4.1999 |
| 36. | Shri S.N. Shah | Scientist – Gr. IV(5) | 8.6.1999 |
| 37. | Dr. N.V. Desai | Scientist – Gr. IV(5) | 22.4.2000 |
| 38. | Dr. S.H. Zaidi | Scientist – Gr. IV(3) | 27.5.1999 |
| 39. | Dr. K.J. Langalia | Scientist – Gr. IV(3) | 1.2.2000 |
| 40. | Dr. (Ms) R.I. Kureshi | Scientist – Gr. IV(3) | 24.4.2000 |
| 41. | Dr. A.V.R. Redd y | Scientist – Gr. IV(3) | 3.6.2000 |
| 42. | Dr. (Ms) P. Ray | Scientist – Gr. IV(3) | 21.9.2000 |
| 43. | Shri Kirpal Singh | Scientist – Gr. IV(2) | 30.5.1999 |
| 44. | Dr. (Ms) S.C. Mishra | Scientist – Gr. IV(2) | 24.7.2000 |
| 45. | Dr. H.M. Mody | Scientist – Gr. IV(2) | 24.7.2000 |
| 46. | Shri A.A. Shah | Tech. Officer – Gr. III(6) | 1.4.1998 |
| 47. | Shri C.M. Mandalia | Tech. Officer – Gr. III(5) | 6.11.1998 |
| 48. | Dr. R.H. Trivedi | Tech. Officer – Gr. III(5) | 1.3.1999 |
| 49. | Dr. S.A. Chauhan | Tech. Officer – Gr. III(4) | 25.10.1998 |
| 50. | Shri N.J. Dave | Tech. Officer – Gr. III(4) | 1.2.1999 |
| 51. | Ms B.G. Rathod | Tech. Officer – Gr. III(4) | 1.2.1999 |
| 52. | Shri R.J. Tayade | STA– Gr. III(2) | 15.11.1998 |
| 53. | Shri V.P. Boricha | STA– Gr. III(2) | 17.3.1999 |
| 54. | Shri G.N. Pathak | Tech nician Gr. II(3) | 1.1.1996 |
| 55. | Shri J.J. Palania | Technician Gr. II(3) | 1.1.1996 |
| 56. | Shri U.A. Kagadi | Technician Gr. II(3) | 1.1.1996 |
| 57. | Shri C.C. Maniar | Technician Gr. II(3) | 1.1.1996 |
| 58. | Shri R.B. Boricha | Technician Gr. II(3) | 1.1.1996 |
| 59. | Shri K.G. Purohit | Technician Gr. II(3) | 1.1.1996 |
| 60. | Shri V.C. Zala | Technician Gr. II(3) | 1.6.1996 |
| 61. | Shri M.D. Vala | Technician Gr. II(3) | 29.9.1996 |
| 62. | Shri M.J. Baraiya | Technician Gr. II(3) | 1.6.1997 |
| 63. | Shri M.J. Gohel | Technician Gr. II(3) | 6.3.1997 |
| 64. | Shri B.R. Mehta | Technician Gr. II(3) | 22.9.1997 |
| 65. | Shri A.S.S. Ahmed | Technician Gr. II(3) | 7.11.1996 |
| 66. | Shri A.M. Chauhan | Techn ician Gr. II(3) | 2.7.1998 |
| 67. | Shri B.R. Rathod | Technician Gr. II(3) | 1.10.1997 |
| 68. | Shri D.R. Parmar | Technician Gr. II(3) | 20.11.1997 |
| 69. | Shri J.M. Parmar | Technician Gr. II(3) | 27.9.1998 |
| 70. | Shri D.H. Khokhar | Technician Gr. II(3) | 25.4.1998 |
| 71. | Shri U.R. Patel | Technician Gr. II(3) | 1.7.1998 |
| 72. | Shri K.C. George | Technician Gr. II(3) | 22.2.1999 |
| 73. | Shri M.N. Makwana | Technician Gr. II(3) | 27.2.1999 |
| 74. | Shri H.H. Patel | Technician Gr. II(3) | 1.10.1998 |
| 75. | Shri D.B. Solanki | Technician Gr. II(3) | 1.3.1999 |
| 76. | Shri D.B. Valodara | Technician Gr. I I(3) | 28.2.1999 |

Acting President,
Jawaharlal Nehru Centre for Advanced Scientific Research,
Indian Institute of Science Campus,
Bangalore 560 012.

Dr. Rajju Shroff, Member

| Sr. No. | Name | Designation | Date of retirement |
|---|---|---|---|
| 1. | Shri K.K. Dodia | Tech. Gr. II(4) | 30.4.2000 |
| 2. | Dr. N.V. Desai | Scientist EII | 31.5.2000 |
| 3. | Shri V.J. Mehta | Tech. Gr. II | 30.6.2000 |
| 4. | Shri H.M Pandya | Tech. Gr. II | 30.6.2000 |
| 5. | Shri H.B. Baraiya | Tech. Gr. I(4) | 31.8.2000 |
| 6. | Shri S.G. Parmar | Tech. Gr.II(5) | 31.8.2000 |
| 7. | Shri P.B. Vithalpura | Assistant | 31.8.2000 |
| 8. | Shri M.J. Dave | Scientist EI | 1.11.2000 |
| 9. | Shri H.J. Padhiyar | Tech. Officer B | 31.10.2000 |
| 10. | Shri K.G. Purohit | Lib. Assistant | 30.11.2000 |
| 11. | Shri K.G. Mer | Assistant | 30.11.2000 |
| 12. | Shri S.N. Shah | Scientist EII | 31.1.2001 |
| 13. | Shri L.G. Ghoghari | Tech. Gr.I | 1.3.2001 |
| 14. | Shri P.R. Hakani | Junior Security Guard | 28.2.2001 |
| 15. | Shri T. Thankachan | Tech. Gr. II(4) | 31.3.2001 |
| 16. | Shri J.L. Bhat | Technician Gr.II(5) | 30.4.2001 |
| 17. | Shri S.G. Devmorari | Technician Gr.II(4) | 30.4.2001 |
| 18. | Shri R. ramamurthy | Assistant | 30.4.2001 |
| 19. | Shri P. Krishnan | Administrative Officer | 31.5.2001 |
| 20. | Shri V.C. Havalia | Technician Gr.II(4) | 30.6.2001 |
| 21. | Shri P.B. Kanada | Technician Gr.II(4) | 30.6.2001 |
| 22. | Shri P.A. Kanada | Technician Gr. II(3) | 30.6.2001 |
| 23. | Dr. R.M. Oza | Scientist Gr. IV(4) | 30.9.2001 |
| 24. | Shri Y.J. Shah | Technician Gr. I(4) | 30.11.2001 |
| 25. | Shri Gova Mala Baraiya | Safaiwala | 30.11.2001 |
| 26. | Shri P.K. Shah | Assistant | 3.12.2001 |
| 27. | Shri D.K. Gohil | Technician Gr. III(3) | 31.1.2002 |
| 28. | Shri H.N. Shah | Scientist Gr. IV(4) | 31.1.2002 |
| 29. | Shri R.J. Joshi | Assistant | 28.2.2002 |
| 30. | Shri B.G.Rathod | Tech. Gr.III(4) | 31.3.2002 |

CMD, United Phosphorus Ltd.,
Madhu Park, 11th Road, Khar (W),
Mumbai 400 052.

| Name | Designation | Transferred to | Date |
|---|---|---|---|
| Shri S. Mazumdar | Section Officer | Regional Research Laboratory, Bhopal | 31.8.2000 |
| Shri N. Radhakrishnan | Driver | Regional Research Laboratory, Thiruvananthapuram | 1.9.2000 |
| Shri S.K. Thakur | Assistant F&A | CSIR Hqrs, New Delhi | 24.11.2000 |

Mr. Kaushal Goel, Member
General Manager, Engineering Projects (India) Ltd.,
B-10, Ho Chi Minh Sarani, Calcutta 700 071.

Dr. G. Subramanian, Member
Director, National Facility for Marine Cyanobacteria,
Bharatidasan University, Tiruchirapalli 620 024 (T.N)

Dr. B.M.Mishra,
Member

Head, Desalination Division,
Bhabha Atomic Research Centre,
Trombay, Mumbai 400 085

Dr. V.Sampath, Member
Director, ICMAM Project Directorate,
NIOT Campus, Velacherry Tambaram Main Road,
Pallikaranai, Chennai - 601 302.

Dr. Sushil Kumar, Member
Director,
Central Institute of Medicinal andAromatic Plants,
P.O CIMAP, Lucknow 226 015 (UP).

Prof. B.M.Mandal, Member
Polymer Science Unit,
Indian Association for the Cultivation of Science,
2 A & B Raja Subodh Mullick Road,
P.O Jadavpur University, Calcutta 700 032

Dr. Pushpito K. Ghosh Member
Director,
Central Salt & Marine Chemicals Research Institute,
Gijubhai Badheka Marg,
Bhavnagar 364 002

Mr. R.R.Hirwani, Member
Scientist 'F', (DG's Nominee)
National Chemical Laboratory,
Pune 411 008.

Mr. S.N.Ghosh Secretary
Scientist, Central Salt & Marine Chemicals Research Institute,
Gijubhai Badheka Marg, Bhavnagar 364 002

Research Council (From 1.1.2001)

Prof. V.Krishnan, Chairman
Acting President,
Jawaharlal Nehru Centre for Advanced Scientific Research,
Indian Institute of Science Campus,
Bangalore 560 012.

Dr. G. Subramanian, Member
Director,
National Facility for Marine Cyanobacteria,
Bharatidasan University, Tiruchirapalli 620 024 (T.N)

Prof. K.D.P. Nigam Member
Head, Dept. of Chemical Engineerin,
B-10, Ho Chi Minh Sarani, Calcutta 700 071.

| | |
|---|---|
| Prof. Kasturi Dutta,<br>School of Environmental Sciences,<br>Jawaharlal Nehru University, New Delhi 110 067 | Member |
| Dr. Sumit Bhaduri<br>Head of R&D, Reliance Industries Ltd.,<br>Swastik Mill Compound, V.N.Purav Marg,<br>Chembur, Mumbai 400 071 | Member |
| Dr. George, John Advisor<br>Dept. of Biotechnology,<br>Block 2, 7-8th Floor, CGO Complex, Lodi Road<br>New Delhi 110 003 | Member |
| Dr. V.Sampath,<br>Director, Project Directorate, (ICMAM), DOD,<br>NIOT Campus, Velacheyy-Tambaram Main Road,<br>Narayanapuram, Pallikaranai,<br>Chennai 601 302 | Member |
| Dr. S. Sivaram<br>Director Grade Scientist,<br>National Chemical Laboratory,<br>Pune 411 008. | Member |
| Dr. Pushpito K. Ghosh,<br>Director,<br>Central Salt & Marine Chemicals Research Institute,<br>Gijubhai Badheka Marg, Bhavnagar 364 002 | Member |
| Mr. S.N. Sharma<br>Scientist, RPBD,<br>Council of Scientific & Industrial Research,<br>Anusandhan Bhavan, 2, Rafi Marg,<br>New Delhi 110 001. | DG's Nominee |
| Mr. S.N. Ghosh<br>Scientist,<br>Central Salt & Marine Chemicals Research Institute,<br>Gijubhai Badheka Marg, Bhavnagar 364 002 | Secretary |

<u>Management Council</u> (Till 30.6.2001)

| | |
|---|---|
| Dr. Pushpito K.Ghosh,<br>Director,<br><br>CSMCRI, Bhavnagar | Chairman |
| Shri V.J. Shah,<br>Scientist F,<br>CSMCRI, Bhavnagar | Member |
| Dr. R.V.Jasra, | Member |

Scientist F,
CSMCRI, Bhavnagar

Shri S. N. Ghosh, Member
Scientist EII,
CSMCRI, Bhavnagar

Shri M.R.Gandhi, Member
Scientist EII,
CSMCRI, Bhavnagar

Shri. J.B. Pandya Member
Scientist EII,
CSMCRI, Bhavnagar

Dr. (Mrs) Paramita Ray Member
Scientist C,
CSMCRI, Bhavnagar

Shri S.N. Patel Member
Tech. Gr. III(2)
CSMCRI, Bhavnagar

Mr. M.K. Jain Member
Sr. Finance & Accounts Officer
CSMCRI, Bhavnagar

Mr. C. Badrinath Member
Secretary
Controller of Administration
CSMCRI, Bhavnagar

Management Council (From 1.7.2001)

Dr. Pushpito K.Ghosh, Chairman
Director,
CSMCRI, Bhavnagar

Shri K.M. Majeethia, Member
Scientist F,
CSMCRI, Bhavnagar

Dr. R.V.Jasra, Member
Scientist F,
CSMCRI, Bhavnagar

Shri S.N.Ghosh Member
Scientist EII,
CSMCRI, Bhavnagar

Dr. (Mrs.) K.H. Mody, Member
Scientist EII,

CSMCRI, Bhavnagar.

| | |
|---|---|
| Dr. V. P. Mohandas,<br>Scientist EI,<br>CSMCRI, Bhavnagar | Member |
| Dr. J.V. Prasad,<br>Scientist EI<br>CSMCRI, Bhavnagar | Member |
| Shri S.N.Patel,<br>Tech. Gr. III(2),<br>CSMCRI, Bhavnagar | Member |
| Shri M.K. Jain<br>Sr. Finance & Accounts Officer<br>Finance & Accounts Officer,<br>CSMCRI, Bhavnagar | Member |
| Shri S. Mohanasundaram<br>Controller of Administration<br>Administrative Officer, | Member-Secretary |

## STAFF STRENGTH

## BUDGET (FROM CSIR)

(Rs. Lakhs)

| Category | Persons on roll as on | |
|---|---|---|
| | 31.3.2001 | 31.3.2002 |
| Scientific | | |
| Group IV | 89 | 92 |
| Technical | | |
| Group III | 38 | 39 |
| Group II | 85 | 78 |
| Group I | 26 | 25 |
| Group V | 3 | 3 |
| Total (Technical) | 152 | 145 |
| Non-technical | | |
| Group A | 3 | 2 |
| Group B | 36 | 34 |
| Group C | 18 | 17 |
| Group D | 25 | 24 |
| Total (Non -technical) | 82 | 77 |
| Total | 323 | 314 |
| Scientist Fellow (Quick hire) | 02 | 01 |
| Research Associate (RA)/Sr. RA | 04 | 05 |
| Research Fellows (JRF/SRF) | 08 | 09 |
| Project Assistants | 37 | 43 |
| Others (project related) | 09 | 08 |
| | 60 | 66 |

| Budget Heads | 2000-01 | 2001-02 |
|---|---|---|
| Equipment - P15, P5(3) etc. | 259 | 321 |
| Infrastructure/ facilities -P5(1), & P5(2) | 81 | 62 |
| Library books - P5(4) | 65 | 71 |
| Chemicals & Consumables – (P7) | 85 | 97 |
| Manpower related expenditure -(P1,P2 & P3) | 500 | 517 |
| Residual - (P4, P6, etc.) | 133 | 113 |
| Total | 1123 | 1181 |