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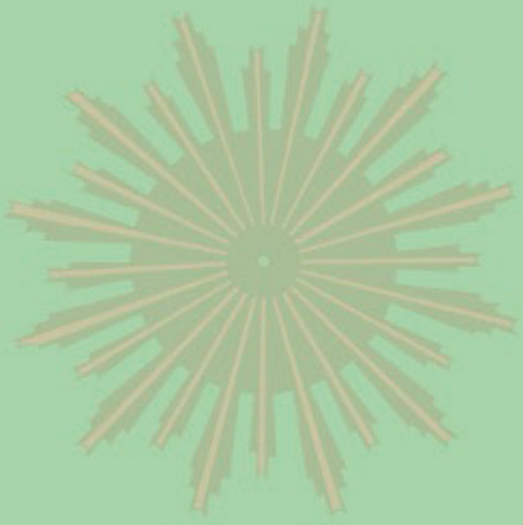

A Publication on
Science & Social Science and Humanities
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BARASAT GOVERNMENT COLLEGE

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From the Principal's & Chief Editor's Desk

Aureole, *the peer reviewed academic Journal published since 2009, by Barasat Government College for Science and Humanities has left an indelible mark in the field of intellectual discourses.*

Selection of articles always are made stressing on academic and innovative ideas and is dedicated in the fields of both Science & Humanities and Social Sciences.

Being a Peer reviewed journal, no stone is left unturned to maintain its standard high. The reviewers, all eminent scholars in their own fields, gave thorough consideration to every aspect of the articles under scrutiny without any killing of time considering our busy and tight schedule. The end result is, we hope, publication of this journal that can stand out in the field of intellectual discourse and development.

Yours obediently deeply expresses his gratitude to all those eminent scholars.

Our contributors too exuberantly have made the suggested corrections and revisions of their articles within a very short notice. A special word of thanks to our editorial team who spent hours of their valuable time in completing the necessary work in order to get the journal into shape.

Yours obediently tenders his apology for any mistakes that might have been overlooked. We welcome advice and suggestions from our readers, other stakeholders and contributors to accelerate the Journal to a greater academic height.

Barasat

Dr. Samar Chattopadhyay
Principal & Chief Editor
[West Bengal Senior Education Service]

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সারসংক্ষেপ: সভ্যতার আদিলগ্ন থেকে ক্রমপরিবর্তনের মধ্য দিয়ে মানুষ সামাজিক হয়ে উঠেছে। পরিশীলিত হতে হতে বিভিন্ন রীতি-নীতি, আচার-সংস্কার জীবনের অঙ্গ করে নিয়েছে। বিবাহ প্রতিটি জনজাতির একটি প্রাচীন সামাজিক রীতি বা প্রথা। অতুল সুর মতে, "হিন্দু সমাজে বিবাহ একটি অত্যন্ত গুরুত্বপূর্ণ ঘটনা। মানুষকে পাপমুক্ত করে বিশুদ্ধিকরণ করবার জন্য হিন্দুর যে দশবিধ সংস্কার আছে তার মধ্যে বিবাহ হচ্ছে শেষ বা চরম সংস্কার।"[১] বিবাহ বন্ধনে আবদ্ধ হলে দুটি নর-নারী একসঙ্গে সামাজিকভাবে বসবাস করার অধিকার লাভ করে। পল্লব সেনগুপ্ত বলেছেন, "মানুষের সভ্যতায় বিবাহ নামক প্রতিষ্ঠানটির যখন পত্তন হয়েছে, বলতে গেলে প্রায় তখন থেকেই এর সঙ্গে সঙ্গে বহু-বিচিত্র আচার, সংস্কারেরও আবির্ভাব ঘটেছে। বিয়ের রীতিনীতির মধ্যে প্রথা এবং বিশ্বাসগতভাবে একটি প্রগাঢ় রক্ষণশীলতার ভাব সব দেশে, সমস্ত সমাজে, সর্বকালেই বজায় থাকে, ব্যবহারিক ভাবে যদি সম্ভব নাও হয়, মানসিকভাবে তো বটেই। জন্ম-মৃত্যু-বিয়ে জীবনের তিনটি সবচেয়ে গুরুত্বপূর্ণ ঘটনাকে কেন্দ্র করে সেইজন্যই অসংখ্য ছোটবড় সংস্কারের সৃষ্টি হয়েছে সমস্ত সমাজেরই লোকমানসে এবং সেগুলিকে উৎসে রেখে গড়ে উঠেছে অজস্র লৌকিক আচার।"[২] উত্তরপূর্ব ভারতের রাজবংশী সমাজে বিয়ের নিজস্ব লোকায়ত রীতিনীতি আছে। মহিলারাই সেই আচার বিচার নিষ্ঠাসহ পালন করে থাকে। যতই যন্ত্রায়নের যুগ আসুক, যতই সমাজ পরিবর্তন হোক তবুও মা, মাসিমা, পিসিমা, কাকিমারা এখনও সন্তানের শুভাশুভের বিষয়টি মাথায় রেখে শুচিতা ও বিশ্বাসের সঙ্গে বিবাহের লোকাচার গুলি নিষ্ঠাভরে পালন করে। রাজবংশী জনজাতির মধ্যে বিয়ের প্রকার ভেদ ছিল বহু। বিধবাবিবাহ, বাল্যবিবাহ, ঘরজায়া বিয়াও, বহুবিবাহ, ছত্রদানী নেওয়া, ভজীর বিয়াও এই বিয়ে গুলির প্রচলন এখন আছে তবে প্রত্যন্ত অঞ্চলে। এই ধরণের বিয়েগুলিতে নিয়মাচারের কড়াকড়ি থাকে না, ঘরজায়া ও বাল্যবিবাহ ব্যতীত। রাজবংশী সমাজে ফুল বিয়েই শাস্ত্রমতে স্বীকৃত বিয়ে। ফুল বিয়ের ক্ষেত্রে শাস্ত্রীয় এবং লৌকিক যাবতীয় নিয়মাচার শুচিতা ও বিশ্বাসের সঙ্গে পালন করা হয়। রাজবংশী জনজাতির বিবাহকেন্দ্রিক যাবতীয় নিয়মাচারগুলি সম্পর্কে জানার আগ্রহ থেকেই আলোচ্য প্রবন্ধের প্রচেষ্টা।

সূচক শব্দ : অপ্রথাগত বিবাহ, ফুল বিবাহ ও প্রাক্কথন পর্ব, প্রাক্‌বিবাহ লোকাচার, বিবাহের লোকাচার, বিদায় পর্ব, বিবাহ পরবর্তী নিয়মাচার।

ভূমিকা

বিবাহ নামক সামাজিক অনুষ্ঠানের মাধ্যমে দুটি নরনারীর মধ্যে সামাজিক বন্ধন রচিত হয়। শুধু দুজন নরনারীর মধ্যেই নয় দুটি পরিবারের মধ্যেও একটি সুন্দর সম্পর্ক স্থাপিত হয়। বন্ধুবান্ধব, আত্মীয়স্বজন, পাড়া- প্রতিবেশী সকলে মিলে শুভ অনুষ্ঠানটিকে আনন্দঘন করে তোলে। সানাই এর সুরে বেদনা ও আনন্দ মিলেমিশে একাকার হয়ে যায়। সেই সঙ্গে শুভাশুভ বিষয়ক কিছু লোকাচার প্রতিটি জনজাতিই পালন করে। উত্তরবঙ্গের রাজবংশী সমাজ এর ব্যতিক্রম নয়। রাজবংশী সমাজের বিয়ের অনুষ্ঠানে নিজস্ব কিছু লোকায়ত রীতিনীতি আছে। এই লোকাচার গুলি পালনের জন্য প্রয়োজন নানান উপকরণের, হলুদ-মেথি বাটা (কুর হলুদ), কলাগাছ, বাঁশপাতা, মাটি, সিঁদুর, চাইলন বাতি, ঘট, আম্রপল্লব, গোবর, দূর্বাঘাস ইত্যাদি। বিবাহ অনুষ্ঠান পরিচালনা করে বৈরাতি, সে যাবতীয় নিয়মাচার পালনের মধ্য দিয়ে বিবাহ অনুষ্ঠান সুসম্পন্ন করে। অনেক সময় বিবাহ অনুষ্ঠানটিকে সুন্দর ও আনন্দময় করে তোলার জন্য মাঝে মাঝে নাচ-গানের আয়োজন করা হয়। রাজবংশী জনজাতির মধ্যে বিয়ের প্রকার ভেদ

ছিল বহু। এই ধরণের বিয়েগুলিতে নিয়মাচারের কড়াকড়ি থাকে না, ঘরজায়া ও বাল্যবিবাহ ব্যতীত। নিচে রাজবংশী সমাজে প্রচলিত বিবাহ এবং পালনীয় লোকাচার গুলি যথাযথভাবে তুলে ধরা হল।

মূল বিষয় আলোচনা

ড. চারুচন্দ্র সান্যাল রাজবংশী সমাজে দুই ধরণের বিবাহের উল্লেখ করেছেন।

১। প্রথাগত বিবাহ

(ফুল বিয়াও): ড. চারুচন্দ্র সান্যাল- "The Rajbansis of North Bengal" গ্রন্থে একমাত্র ফুল বিয়েকে Regular forms of marriage হিসেবে উল্লেখ করেছেন।[৩]

২। অপ্রথাগত বিবাহ

বিদুয়া বা আড়ির বিয়াও, ছত্রদানি বা ভাতার ছাড়ির বিয়াও, ঘর সোন্দানি, ডাঙ্গুয়া, গছ খাড়া বা গাও গছ বিয়াও, ইত্যাদি। রাজবংশী সমাজে কিছুদিন আগে এই বিবাহগুলি নিন্দনীয় ছিল না। সমাজপতি বা দেউনিয়ারা এই বিয়েগুলিকে মান্যতা দিত। মানুষ এখন শিক্ষিত হয়ে উঠেছে সেইজন্য সমাজে এই বিবাহ গুলির প্রচলন নেই বললেই চলে।

অপ্রথাগত বিবাহ

বিদুয়া বা আড়ির বিয়াও

এই বিয়ে রাজবংশী সমাজে প্রচলিত ছিল এবং আছে। বিয়ের পর কোন নারীর অল্প বয়সে স্বামী মারা গেলে এই ধরণের বিয়ে দেওয়ার রীতি প্রচলিত আছে। অনেক সময় দেখা যায় শ্বশুর বাড়ির লোকজন এবং বাপের বাড়ির লোকজন পরামর্শ করে পুনরায় বিয়ে দেওয়ার ব্যবস্থা করত। সেক্ষেত্রে পাত্রটি ফুলপাত্র হয় না, দ্বিতীয় পাত্র বা বয়সে অনেক বড় কোন ঢেনা (যার বৌ বাচ্চা কেউ নেই) ব্যক্তির সঙ্গে বিয়ে দেয়। এই বিয়েতে তেমন আড়ম্বর থাকে না। কোন মন্দিরে গিয়ে মালাবদল করে বিয়ে হয়। অনেকে দ্বিতীয় বিয়ের পর সিঁদুর পরে না। যেমন- কোচবিহার জেলার ফুলবাড়ি গ্রামের নমিতার বর্মনের সঙ্গে ঠাকুর পাটের দিলীপ রায়ের বিয়ে হয় বর্তমান শতকের প্রথম দিকে। বিয়ের এক বছরের মধ্যে দিলীপ মারা যায়। গাবুর আড়ি হয় নমিতা (যুবতী বিধবা নারী)। দুই বাড়ির মতে ভুটনীঘাটের ক্ষিতীশ রায়ের সঙ্গে তার বিয়ে দেওয়া হয়।

ভাউজের বা ভজীর বিয়াও

রাজবংশী পরিবারে বিয়ের কিছুদিনের মধ্যে বড়দাদা মারা গেলে তার স্ত্রীকে ছোট ভাইয়ের সঙ্গে বিয়ে দেওয়া রীতি প্রচলিত ছিল। রক্ষণশীল পরিবারের গৃহকর্তা বা গিন্নি চাইতেন না তাদের বাড়ির বৌ আড়ির মতো জীবন কাটাক বা অন্য কোন বাড়ির বৌ হোক। তখন দুই বাড়ির লোকজন বিবাহের ব্যবস্থা করেন। এক্ষেত্রে দেববের সঙ্গে (ফুলপাত্রের) বিধবা বৌদির (ভজীর) বিয়ে হয়। ছেলেটি বাবা মায়ের মতে বিয়ে করে সুখে সংসার করে। কিন্তু ছোট ভাই মারা গেলে বড় ভাইয়ের সঙ্গে ছোট ভাইয়ের স্ত্রীর সঙ্গে বিয়ে দেওয়া যাবে না। এক্ষেত্রে রাজবংশী সমাজে কড়া নিয়ম প্রচলিত আছে। বড় ভাই ছোট ভাইয়ের স্ত্রীকে ছুঁতে পারবে না। যদি কখনো দুজনের ছোঁয়াছুঁয়ি হয় সেক্ষেত্রে কঠোর নিয়ম প্রচলিত আছে। দুইজনকেই নদীতে গিয়ে স্নান করে এসে গুরুজনের পা ধোয়া জল খেতে হবে। এর কোন অন্যথা হবার নয়। কখনো ভাসুর ঠাকুরের কোমরের গামছায় আগুন লাগিয়ে দেওয়া হয় এবং সে নদীর

জলে ঝাঁপ দেয় তারপর স্নান সেরে ঘরে ফেরে। এই রীতি পঞ্চাশ-ষাটের দশকেও চলন ছিল, আজকাল নেই। তবে গুরজনদের পা ধোয়া জল খাওয়ার প্রচলন এখনো আছে।

ছত্রদানী নেওয়া বা ছত্রদানীর বিয়াও

এই বিবাহ হল বিবাহিত নারীর পুর্নবিবাহ। এক্ষেত্রে নারী-পুরুষ দুজনেই বিবাহিত হতে পারে, তাদের সন্তান-সন্ততি থাকতে পারে অথবা নারীটি বিবাহিত এবং পুরুষটি অবিবাহিত হয়। ধরা যাক কোন নারীর স্বামী বাইরে থাকে বা অসুস্থ থাকে সেক্ষেত্রে নারীটি অন্য পুরুষের প্রতি আকৃষ্ট হয়ে সেই পুরুষের সঙ্গে মালাবদল করে বিবাহ বন্ধনে আবদ্ধ হয়। অথবা কোন পুরুষ কোন নারীর প্রতি আকৃষ্ট হলে তাকে ভুলিয়ে ভালিয়ে নিয়ে এসে মন্দিরে মালাবদল করে বিয়ে করে। এই ধরণের বিয়ে হল ছত্র দানী বিয়ে। নারীটির সন্তান থাকলে বিবাহিত পুরুষটি সেই সন্তানের দায়িত্ব নেয়। সুখে সংসার করে। কিছু দিন আগেও কোচবিহারের প্রত্যন্ত অঞ্চলে এই বিয়ের প্রচলন ছিল।

১। কোচবিহার জেলার মুকুলডাঙার নরেন বর্মনের সঙ্গে মাথাভাঙার শিবপুর গ্রামের মালতি বর্মনের ছত্রদানী বিয়ে বিশ শতকের ষাটের দশকে। তার স্বামী অসুস্থ ছিল। নরেন বর্মন তাকে ভুলিয়ে নিয়ে আসে সুখের সংসার দিবে বলে। মন্দিরে মালাবদল করে বিয়ে করে। মালতির দুটি ছেলে-মেয়ে সঙ্গে করে নিয়ে এসেছিল। এদিকে নরেন বর্মনের আগের স্ত্রীর অনেকগুলি ছেলেমেয়ে ছিল কিন্তু পত্নী ছিল না। দুজনে আমরণ সুখে সংসার করেছে।

২। কোচবিহার জেলার দেওয়ানগঞ্জ মহকুমার হেমকুমারী গ্রামের হেমন্ত রায়ের সঙ্গে শিলিগুড়ি ববিতা বর্মনের ছত্রদানী বিয়ে হয় এই বর্তমান শতকের প্রথম দিকে সালে। মন্দিরে মালাবদল করে। হেমন্ত তাকে সিঁদুর দিতে পারে না এবং তার মাথায় টোপর উঠল না। কেননা ববিতার স্বামী বর্তমান আছে। ববিতার দুটি ছেলে-মেয়ে রয়েছে কিন্তু সে তাদের বাবার কাছে রেখে হেমন্ত বর্মনের সঙ্গে সংসার পেতেছে। স্বামী নিতে এলেও সে তার কাছে ফিরে যায় নি, এমনকি ছেলে মেয়েদের কথাও ভাবে নি।

ঘরজায়া বা ঘরজামাই

রাজবংশী সমাজে 'ঘরজায়া' বা 'ঘরজামাই' রাখার প্রথাটি খুবই অভিনব। সাধারণত দেখা যায় কোন বড় ঘরের মেয়ের বিয়ে হচ্ছে না বা বিয়ের বয়স চলে গিয়েছে বা দেখতে কুৎসিত সে ক্ষেত্রে বাড়ির গুরুজনেরা অকর্মন্য দরিদ্র ঘরের কোন ছেলেকে ঘরজামাই রেখে তার যাবতীয় ভরণপোষণের দায়িত্ব বহন করে। ঘরজামাই থাকায় তার মানসম্মানের কোন বালাই থাকে না। দীনবন্ধু মিত্রের 'জামাইবারিক' নাটকে ঘরজামাইদের চরম দুর্দশার ছবি দেখতে পেয়েছি। রাজবংশী সমাজ এর ব্যতিক্রম নয়। আবার অনেক ক্ষেত্রে দেখা যায় কোন ধনী পরিবারে শুধুমাত্র কন্যা সন্তানের জন্ম হয়েছে, কোন পুত্র সন্তান নেই। সেক্ষেত্রে বিশাল সম্পত্তি রক্ষণা-বেক্ষণের জন্য একটি মেয়ের জন্য ঘরজামাই রাখার সিদ্ধান্ত নেয়। বড়লোকের কোন ছেলে ঘরজামাই হতে চায় না। বন্ধুবান্ধব ও আত্মীয়স্বজনের সহায়তায় একটি গরীব, অনাথ, পিতৃ-মাতৃহীন ছোট ছেলে খুঁজে বাড়িতে নিয়ে আসে। পিতৃ স্নেহে বড় করে তোলে। তারপর তাকে বাড়ির যাবতীয় কাজ-কর্ম আদব কায়দা শেখানো হয়। কিন্তু তখনও তাকে জানানো হয় না বাড়ির কোন মেয়ের সঙ্গে তার বিয়ে হবে। বাড়ির অন্দরমহলে প্রবেশ করলেও কারো সাথে মেলামেশা করার অধিকার দেওয়া না। ছেলেটি ক্রমশ যুবক হয়ে উঠলে বাড়ির কর্তা মনে করেন এবার বিয়ে দেওয়ার সময় হয়েছে। তখন যে মেয়ের সঙ্গে বিয়ে দেবার জন্যে ছেলেটিকে এনেছিল তার সঙ্গে বিয়ের আয়োজন করে। আত্মীয়স্বজন, পাড়া প্রতিবেশী নিমন্ত্রন করে জাঁকজমকভাবে ও ধুমধাম করে যাবতীয় নিয়মাচার পালন করে বিয়ের অনুষ্ঠান সম্পন্ন হয়। পিতৃ-মাতৃহীন ছেলেটির দুরসম্পর্কের কোন আত্মীয় স্বজন থাকলে বিয়েতে তাদের নিমন্ত্রন করা হয়। এরপর থেকে সে শ্বশুর বাড়িতে ঘরজামাই হিসেবে থাকে। রাজবংশী সমাজে এই ধরনের বিয়ে কিছুদিন আগে প্রচলিত ছিল। প্রিয়বালা অধিকারী সঙ্গে রসিকান্ত

অধিকারীর বিয়ে ঘরজায়া বিয়ের প্রকৃষ্ট উদাহরণ। মাধব অধিকারী প্রায় দুশো বিঘে জমির মালিক। তাঁর চার কন্যা, কোন পুত্র সন্তান নেই। তিন মেয়ের বিয়ে দেয় অন্যত্র। ছোট মেয়ে প্রিয়বালার সঙ্গে রসিকান্তর বিয়ে দিয়ে বাড়িতে ঘরজামাই করে রেখে দেয়। রসিকান্তর খুব ছোটবেলায় বাবা-মা মারা যায়। দুরসম্পর্কের এক মামা তাকে নিয়ে আসে নিজের কাছে সেখানে অনাদরে বড় হতে থাকে। মাধব অধিকারী এই ছেলেকেই বাড়িতে নিয়ে আসে এবং গড়ে পিঠে মানুষ করে নিজের মেয়ের সঙ্গে বিয়ে দেয়। দীর্ঘজীবন বিশাল সম্পত্তির মালিক হয়ে সুখে স্বচ্ছন্দে সংসার জীবন অতিবাহিত করে।

বাল্যবিবাহ : রাজবংশী সমাজে সাধারণত মেয়েদের ১৬ থেকে ১৭ বছর বয়স হলেই বিয়ে দেওয়ার রীতি প্রচলিত। বাপের চিন্তা 'বেটি বড় হইসে বিয়াও দিবার নাইগবে'। যদিও এখন অনেক পিতা মাতা শিক্ষিত ও সচেতন ফলে ১৮ থেকে ২০ মধ্যেই বিয়ে দেয়। কিন্তু প্রত্যন্ত অঞ্চলে এখন বিয়ের বয়স হওয়ার আগেই বিয়ে দেয়। অনেক সময় অর্থের লোভে কন্যার পিতা বয়সে অনেক বড় দ্বিতীয়া বরের সঙ্গে মেয়ের বিয়ে দেন। এই রীতি কিছুদিন আগেও প্রচলিত ছিল। বাল্য বিবাহের ক্ষেত্রে অনেক সময় দেখা যায় দুইবন্ধু সন্তান জন্মানোর আগেই ঠিক করে দুজনের মধ্যে একজনের ছেলে অন্যজনের মেয়ে হলে বিয়ে দিয়ে বন্ধুত্বের সম্পর্ককে আত্মীয়তায় পরিণত করবে। ঈশ্বরের কৃপায় তাদের চাওয়া যদি সত্যি হয় তবে খুব ছোট বয়সে বিয়ের যাবতীয় নিয়মাচার পালন করে দুজনের বিয়ে দেওয়া হয়। দুজনে যথারীতি বড় হয়ে ওঠে। তারা জানেও না তারা স্বামী-স্ত্রী। বিয়ের বয়স হলে পুনরায় সামাজিকভাবে তাদের বিয়ে দেওয়া হয়। এই বিয়ের কুফল আছে মেয়ে বা ছেলে যৌবনে পদার্পণ করলে অন্য ছেলে মেয়ের সঙ্গে সম্পর্ক গড়ে ওঠে সেক্ষেত্রে বিবাহ বিচ্ছেদ ঘটে। এই প্রথা বর্তমানে নেই বললেই চলে। তবে ফুলবাড়ি গ্রামের সুশীল বর্মনের মেয়ে জ্যোৎস্নার সঙ্গে পাশের বাড়ির খগেশ্বর বর্মনের বেটা শিবচরণের বিয়ে এই বিয়ের একটি উদাহরণ। বিগত শতকের নব্বইয়ের দশকের ঘটনা। ছোট বেলায় তাদের বিয়ে হয় কিন্তু যৌবনে শিবচরণ অন্য একটি মেয়েকে বিয়ে করে সুখে সংসার পাতে। জ্যোৎস্নারও অন্যত্র বিয়ে হয়। বন্ধুত্বের সম্পর্ক নষ্ট হয়ে যায়। এছাড়াও ডাঙ্গুয়া সোন্দা, সাংনা ভাতার প্রভৃতির মাধ্যমে দুটি পুরুষ নারী একত্রে বাস করতে পারে। সেক্ষত্রে সমাজের দেউনিয়ার আদেশে লোকজন তাদের মন্দিরে গিয়ে মালাবদল করার ব্যবস্থা করে দেয় এবং এরা সমাজে বসবাস করার স্বীকৃতি লাভ করে। এ নিয়ে রাজবংশী সমাজে প্রবাদ প্রচলিত আছে,

" সাংনা ভাতার চ্যারার মাটি
থোরোত কৈত্তে ধরে নাটি।" [৪]

ফুলবিবাহ

ফুল বিয়ে রাজবংশী সমাজে প্রথাগত বিবাহ অনুষ্ঠান। দুটি অবিবাহিত ছেলে-মেয়ের শাস্ত্র মতে বিবাহ সম্পন্ন হয়। এই বিয়ের অনুষ্ঠানে রাজবংশী সমাজে প্রচলিত লোকাচারগুলি নিষ্ঠাসহকারে পালন করা হয়। কয়েকটি পর্বে বিবাহ অনুষ্ঠানটি সংঘটিত হয়। রাজবংশী সমাজে বিবাহের যোটককে বলা হয় কাড়োয়া বা ঘটক। কাড়োয়া বর-কনে দুইপক্ষে কথা আদান প্রদান করে। কাড়োয়া কখনো নিজে উপযাজক হয়ে বর-কনের বাড়িতে সম্বন্ধ নিয়ে আসে। কখনো কোন ছেলের বাপের মেয়ে পছন্দ হলে ঘটকের মাধ্যমে মেয়ের বাড়িতে সম্বন্ধ স্থাপনের সংবাদ পাঠান। কন্যাপক্ষ রাজি হলে দেখাদেখির পর্ব শুরু হয়।

প্রাক্‌কথন বা আলাপ-আলোচনা পর্ব

ফুলদেখা

এই পর্বটি প্রথমে মেয়ের বাড়িতে হয়। ছেলে পক্ষ থেকে কাড়োয়া ছেলের বাবা, জ্যাঠা, কাকা, মামা এবং পিসা গুরুজনদের নিয়ে মেয়ের বাড়িতে আসেন। বাড়ির প্রবেশ মুখে এক বালতি জল রাখা হয়। সেই জলে পা ধুয়ে বাড়িতে প্রবেশ করার রীতি প্রচলিত। বরপক্ষকে প্রথমে বৈঠকখানা বা ডারিয়া ঘরে বসালেও পরে মেয়ে দেখার জন্য উঠানে তুলসীতলার সামনে শতরঞ্চি বা মাদুর পেতে তার উপর চাদর (পান্না) বিছিয়ে দেওয়া বিছানায় বসেন। মেয়ে দেখার পর্ব শুরু হয়। মেয়েটি কাঁসার বাটায় পান সুপারি নিয়ে বের হয়। প্রথমে পান সুপারির বাটাখানা তুলসীতলায় রেখে হাটুগেড়ে প্রণাম করে। তারপর সেই বাটা বরপক্ষের সামনে রেখে একই ভাবে বাবা এবং সবাইকে প্রণাম করে। আগে থেকে রাখা পিঁড়ি কিংবা জলচৌকিতে মেয়েটি বসে। বরের বাবা মেয়েটির নাম, কয় ভাই বোন, বাবা কি করে প্রভৃতি জিজ্ঞাসা করে। দেখা হয়ে গেলে মেয়েটি আর একবার প্রণাম করে পানের বাটা নিয়ে ঘরে চলে যায়। পানের বাটায় মুখদেখানির অর্থমূল্য দেওয়ার প্রচলন এখনো আছে। বরপক্ষকে চা বিস্কুট পরিবেশন করা হয়। সেদিন বিয়ের আর কোন কথাবার্তা হয় না। শুভাশুভের জন্য তিনদিন রাখা হয়। এই তিনদিনের মধ্যে দুই বাড়িতে যদি কোন দুর্ঘটনা ঘটে, আগুন লেগে কিছু পুড়ে যায়, কাপড় ছিঁড়ে যায়, কাপ ভাঙে তবে বিয়ের কথা আর এগোয় না। বাড়িতে প্রবেশের মুখে কোদাল, কুড়াল, দা, ঝাড়ু দেখা অমঙ্গলসূচক ধরা হয়। আবার যাওয়ার পথে ভরা কলসি, মৃতমানুষ, জ্বলন্ত চিতা এবং সাপ ইত্যাদি দেখা শুভ হিসেবে ধরে নেওয়া হয়। রাজবংশী সমাজে এই নিয়মগুলি কম বেশি মেনে চলে। তিথি নক্ষত্র দেখে যাত্রা করার রীতি তো আছেই। রাজবংশী সমাজে এই বিষয়গুলি গুরুত্ব সহকারে ভাবা হয়। সমাজে অনেক পরিবর্তন এসেছে তবুও বয়স্ক মহিলারা (মা, মাসি, পিসি) এইসব লোকাচার নিষ্ঠার সঙ্গে পালন করার চেষ্টা করেন। তারা বিশ্বাস করেন- জন্ম, মৃত্যু, বিয়ে তিন বিধাতা নিয়ে। সবকিছু ঠিক থাকলে তিনদিন পরে কাড়োয়া নিজে এসে মেয়ের বাড়িতে খবর দেয়। তখন মেয়ে পক্ষ ছেলে দেখতে যায়। সেক্ষেত্রে একই নিয়ম পালন করা হয়। দুপক্ষের পছন্দ হলে কাড়োয়া সেই সংবাদ উভয়পক্ষকেই জানিয়ে দেয়। পাকা দেখার প্রস্তুতি শুরু হয়।

পাকা দেখা

পাকা দেখার ক্ষেত্রে ছেলের বাড়ির লোকজন এমনকি ছেলে নিজেও আসে মেয়ে দেখতে। মা, মাসি, পিসি বাড়ির অন্দরমহল পর্যন্ত প্রবেশ করে। সব কিছু ভালো করে দেখে নেয়। মাথার চুল থেকে পায়ের নখ পর্যন্ত। পাকা দেখায় একটি বড় কাঁসার থালায় চাল দিয়ে দুটি মাটির প্রদীপ, দুই জোড়া পানসুপারি, একশ টাকা দিয়ে চাইলন সাজানো হয়। মেয়ে সেই চাইলন নিয়ে বের হয়। তুলসীতলায় সেই চাইলন বাতি রেখে হাটু গেড়ে প্রণাম (ভক্তি দেওয়া) করে। তারপর শতরঞ্চির উপর সুন্দর ফুলতোলা চাদর বিছানো বিছানায় (কোন কোন বাড়িতে গদি বিছিয়ে সাথে বালিশ দেওয়ার রেওয়াজ আছে) বসে থাকা সকলের উদ্দেশ্যে প্রণাম করে একটি পিঁড়ি বা জলচৌকিতে গিয়ে বসে। ছেলের বাড়ির গুরুজন মহিলারা মেয়েটি কি কি কাজ পারে তা যাচাই করে নেয়। পাকা দেখার পর্ব শেষ হলে পুনরায় প্রণাম করে চাইলন নিয়ে ঘরে চলে যায়। চাইলনে কন্যাপক্ষ একশ টাকা দিলে বরপক্ষকে দুইশত অর্থাৎ দ্বিগুণ টাকা দেওয়ার রীতি প্রচলিত। এটা বরপক্ষের সম্মানের বিষয়। পাকা দেখায় আহারাদির বিশাল আয়োজন করা হয়। আত্মীয় স্বজন পাড়াপড়শিতে বাড়ি গম গম করে। ছেলের বাড়ির অনেকে মেয়ের সঙ্গে গল্প করে। বরপক্ষের ক্ষেত্রে একই নিয়ম, এর অন্যথা হয় না। ঐ দিনই ছেলের বাড়িতে যৌতুক অর্থাৎ দেনাপাওনার বিষয় ঠিক হয়। কিছু দিন আগে রাজবংশী সমাজে কন্যা পণ বা

'খালতি' দেওয়ার প্রথা প্রচলিত ছিল। কন্যার মা কন্যাপণ নিতেন। এখন এই প্রথা সমাজ থেকে উধাও। ধনী লোকেরা মেয়ের বিয়েতে পাত্রপক্ষ না চাইলেও কাঠের আসবাবপত্র এবং প্রচুর সোনার গয়না যৌতুক দিত। টাকা দেওয়ার প্রচলন ছিল না। সমাজ পরিবর্তন হচ্ছে এখন বরপণ দেওয়া বিপুল পরিমাণে বেড়ে গেছে। অদূর ভবিষ্যতে কি হবে তা সময় বলবে।

বাগদান

বাগদান পর্বটি ছেলের বাড়িতে অনুষ্ঠিত হয়। বাগদানের সময় ছেলেকে নতুন জামাকাপড় পড়ে তুলসীতলায় বসানো হয়। কনের পিতা পাঁচ কাপড় ও সোনার আংটি দিয়ে ছেলে আশীর্বাদ করেন। বাড়ির গুরুজনেরা ধান দূর্বা দিয়ে ছেলেকে আশীর্বাদ করেন। বতর্মানে টাকা বা শার্ট স্যুটের কাপড় দিয়ে আশীর্বাদ করার রীতি প্রচলিত হয়েছে। আশীর্বাদ পর্ব শেষ হলে বাড়ির নারীরা ছেলের গায়ে হলুদ মাখায়। কনের বাড়ির লোকেদের গায়েও হলুদ লাগানোর রীতি প্রচলিত। গোটা অনুষ্ঠানটি জাঁকজমক এবং হাস্য আমোদের মধ্য দিয়ে সম্পন্ন হয়। মেয়ের বাড়ি থেকে পানসুপারি, বাতাসা, নানা ধরণের মিষ্টি, বড় রুই মাছ নিয়ে যাওয়া হয়। বরের পিতা এবং কন্যার পিতা বিয়াই সম্পর্কে আবদ্ধ হয়। পরস্পর পরস্পরকে আলিঙ্গন করে। মুখোমুখি একসাথে হাটু গেড়ে প্রণাম করে।

নিরক্ষণী বা সোনা কাপড়

এই অনুষ্ঠান মেয়ের বাড়িতে হয়। বলা ভালো প্রাক্ বিবাহ অনুষ্ঠান পর্ব। আত্মীয় স্বজন, পাড়া প্রতিবেশীদের আমন্ত্রন জানানো হয়। মেয়েকে সোনার গয়না এবং লাল অথবা হলুদ শাড়ি পড়িয়ে সুন্দর করে সাজানো হয়। মেয়েকে তুলসীতলায় বসানো হয়। বরের বাবা-মা মেয়েকে সোনার হার অথবা কানের দুল দিয়ে আশীর্বাদ করেন। মা, মাসি এবং পিসি কনের গায়ে হলুদ লাগায়। সেই হলুদ বরপক্ষের সকলকে লাগানো হয়। অনেকের বাড়িতে ছেলেও আসে সেক্ষেত্রে বর-কনের মালাবদলের মাধ্যমে বিবাহের শুভ সূচনা হয়। উলুধ্বনি, শঙ্খধ্বনি, হাসির কলতানে এবং আনন্দময় পরিবেশে সোনা কাপড়ের শুভ অনুষ্ঠান সম্পন্ন হয়। সেই দিনই পঞ্জিকা দেখে বিয়ের দিন ধার্য করা হয়।

প্রাক্‌বিবাহকেন্দ্রিক লোকাচার

রাজবংশী সমাজের বিয়ের যাবতীয় লোকাচার বাড়ির নারীরাই সম্পন্ন করে। সেই সঙ্গে থাকে রঙ্গ রসিকতা থেকে হাসি কান্না বিষয়ক নাচগান। দেশি বাজনা ঢোল, করকা এবং সানাইয়ের সুরে বিয়ে বাড়ির মহল আনন্দে ভরে ওঠে। বিবাহের যাবতীয় নিয়মাচার পালন করে বৈরাতি। বর-কনে দুপক্ষে বৈরাতি থাকে। সাত দিন আগে থেকে চাইলন কুলা সাজানোর কাজ শুরু করে। বিয়ের দুদিন আগে সাইটোল বিষহরি পূজা এবং অন্যান্য দেবদেবীর পূজা সম্পন্ন করে বাড়ির কর্তা-গিন্নি। যেকোন শুভ অনুষ্ঠানের শুরুতে সাইটোল বিষহরি পূজা রাজবংশী করতে হয়। আত্মীয়-স্বজন আসতে শুরু করে। তাদের আগমন এবং আমোদ-প্রমোদের মধ্য দিয়ে এক অনাবিল পরিবেশ সৃষ্টি হয়।

রাজবংশী প্রাক্‌বিবাহের লোকাচারগুলিকে কয়েকটি পর্বে ভাগ করে আলোচনা করতে পারি-

নাউয়াকামানি

বিয়ের প্রথম আচার হল নাউয়াকামানি। বিবাহের দিন সকাল বেলা 'নাউয়াকামানি' অর্থাৎ নাপিত বাড়িতে এসে বর-কনের নখ ও চুলে ক্ষুর ছুঁয়ে দেয়। হাতে ধরিয়ে দেয় দর্পণ এবং আম্রপল্লব। এরপরই শুরু হয় যাবতীয় আচার অনুষ্ঠান। সেই সময় বৈরাতি উলু দেয়, গান গায়-

চালত কান্দে কাউয়া/মাটিত ক্ষুর ধরে নাউয়া। ভালো করিয়া কামাও রে নাউয়া/ ভালো ধুতি পাবু।

পুকুর খনন

বর-কনের জামাইবাবু (বনু বা বোনাই) পুকুর খননের কাজটি সম্পন্ন করেন। উত্তর ঘরের দরজার দুইপাশে একটি করে কলাগাছ পুঁতে দেওয়ার নিয়মটিও জামাইবাবুই সম্পন্ন করে। কলাগাছের নিচে দেওয়া হয় ধান, সেই ধানের উপর একটি জলভরা ঘট আম্রপল্লবসহ খুব সাবধানে বসানো হয়। সেই ঘট যেন পড়ে না যায়। দরজার বাম পাশে জামাইবাবু একটি ছোট পুকুর খনন করে তাতে কচুরিপানা ও বাঁশের পাতা দেওয়া হয়। অনেকে সময় ছোট মাছ ছেড়ে দেয়। বর-কনের অধিবাস, বাসি বিয়ের যাবতীয় আচার এই পুকুর পারে অনুষ্ঠিত হয়। গোটা বিষয়টির মধ্যে উর্বরা তন্ত্র বা প্রজনন ভাবনা লুকিয়ে আছে।

কুর হলুদ বাটা

বৈরাতি বিয়ের আগের রাতে একটি বাটিতে মেথি এবং কাঁচা হলুদ ভিজিয়ে রাখে। বিয়ের দিন সকালবেলায় পাঁচজন অবিবাহিত মেয়ে একটি কাঠের পিঁড়িতে মেথি এবং কাঁচা হলুদ একসঙ্গে বাটে তাতে সরিষার তেল ঢেলে মেখে রাখলে তৈরি কুর হলুদ বাটা। এই কুর হলদ বাটা নারদের ভাড়ের সঙ্গে কনের বাড়িতে পাঠানো হয়। অধিবাসের সময় বর-কনের গায়ে এই কুর হলুদ মাখানো হয়।

হরগৌরী পূজা ও শ্রাদ্ধাদি

বৈরাতি উত্তর ঘরের দেওয়ালে মাটির দলয় কড়ি বসিয়ে দেয় হরগৌরীর প্রতীকরূপে। বর-কনে দুজনকে এই হরগৌরী পূজা করতে হয়। ব্রাহ্মণ এই মন্ত্র উচ্চারণের মাধ্যমে পূজা সম্পন্ন করেন। বর- কনে দেবতার কাছে একমনে সুখী দাম্পত্য জীবন প্রার্থনা করে। পূজা শেষে গোবরের বল নির্মাণ করেবরের মাথায় বসিয়ে কয়েকটি দূর্বা ঘাসের আগা একসাথে বেঁধে বাটিতে রাখা সরিষার তেল পাঁচজন কুমারী মেয়ে পাঁচবার বরের মাথায় ছুয়ে দেয়। একই সময় বর-কনের পিতা পূর্বপুরুষের উদ্দেশ্যে শ্রাদ্ধাদি পিন্ডদান পর্বটি ব্রাহ্মণের মন্ত্র উচ্চারণের মধ্যদিয়ে সম্পন্ন করেন।

জল বরণ

বর-কনের অধিবাসের জন্য পাশের কোন নদী বা জলাশয় থেকে জল আনার প্রথা প্রচলিত আছে। বৈরাতি চাইলন বাতি নেয়, কেউ নেয় ফুল ও ধুপকাঠি, কেউ নেয় কাঁসার কলসি। সাথে বাজনার দলও যায়। বাজনার তালে নারীরা নাচে। বৈরাতি কলসিতে জল ভরার পর ধুপকাঠি জ্বালিয়ে পাঁচবার নদীকে চাইলন বাতি দেখায়। তারপর একটি মাটির প্রদীপ ও ফুল নদীর জলে ভাসিয়ে দেওয়া হয়। বৈরাতি জলভরা কলসি তুলসী তলায় এনে রাখে।

অধিবাস

সন্ধ্যায় অধিবাস পর্বের শুরু হয়। বর-কনেকে জামাইবাবু কোলে তুলে খনন করা পুকুরের পারে নিয়ে গিয়ে একটি পিঁড়ির উপর বসায়। প্রথমে মা কুর হলুদ ছেলের মুখে হাতে লাগিয়ে কলসির জল দিয়ে ধুয়ে আঁচল দিয়ে মুখ মুছে দেয়। দই, ধুপকাঠি, খিলিপান দেখায়। মিষ্টি খাওয়ায়, মুখ ধুয়ে দেয়, মুছে দেয়। একইভাবে মাসি, পিসি ও কাকিমা ছেলের গায়ে হলুদ

লাগায় এবং মিষ্টিমুখ করায়। শেষে বৈরাতি বরের গোটা গায়ে হলুদ লাগায় এবং বরণ করে আনা জল দিয়ে স্নান করায়। কনের বাড়িতেও একই নিয়ম চলে। অধিবাস পর্বটি শেষ হলে জামাইবাবু পুনরায় কোলে তুলে বরকে ঘরে নিয়ে যায়।

বিয়ের ছায়ামন্ডপ বা ছাদনা তলা

বাঁশ কেটে ছনের ছাউনি দিয়ে চৌকো মত ছায়া মন্ডপ বাননো হয়। চার কোণায় পুঁতে দেওয়া হয় চারটি কলা গাছ। তার নিচে আমের পল্লব সহ চারটি জলভরা ঘট বসানো হয়। কাগজের ফুল দিয়ে সুন্দর করে সাজানো হয় মন্ডপের চারিধার। মাঝের অংশে আবির ও চালের গুড়ো দিয়ে আলপনা আঁকা হয়। বিয়ের আসরে সাজানো চাইলনে থাকে ষোলোটিয়া কলার ছড়ি, ধান, মাটির ফুলঝুরি, মাটির প্রদীপ। প্রদীপ যাতে নিভে না যায় সেদিকে বৈরাতি সতর্ক থাকে। কেননা প্রদীপ নিভে যাওয়াকে অমঙ্গল মানা হয়। এই চাইলন বা বরণডালা বর বরণ থেকে শুরু করে বিয়ের যাবতীয় কার্যাদিতে দরকার হয়।

নারদের ভার নিয়ে যাওয়া

বরের ভাগ্নে এই লোকাচারটি পালন করে। বিয়ের দিন সন্ধ্যায় নারদের ভার সাজানো হয়। ভারের একদিকে থাকে এক ঘটি দই, একঝুঁকি পাকা কলা ও একটি গামছা। ভারের অন্য দিকে থাকে পাঁচটি পুটি মাছ, একজোড়া শাঁখা ও পলা, সিঁদুরের কৌটা ও কুর হলুদ বাটা, দুইজোড়া পানসুপারি। বিয়ের অনুষ্ঠানে নারদের ভার বিষয়টি খুবই গুরুত্বপূর্ণ। কারণ নারদের ভার না এলে কখনোই বিয়ে শুরু হবে না। এই জন্য নারদের ভার বরের বাড়ি থেকে আগেই কনের বাড়িতে পাঠানো হয়।

বিবাহ পর্ব

জামাই বরণ ও বিবাহের মন্ত্র পাঠ

বরযাত্রী এলে কনের মা চাইলন দিয়ে জামাই বরণ করে। সে সময় কনের ছোট বোন নতুন গামছা দিয়ে বরের পা দুটি বেঁধে দেয়। বিবাহ আসরে প্রবেশ মূল্য দাবী করে। বরের বাড়ির থেকে মূল্য দিলেই বোন পায়ের বাঁধন খুলে দেয়। একটি ঘরে নিয়ে গিয়ে কনের বাড়ির ধুতি পাঞ্জাবি পড়িয়ে বিবাহ আসরে নিয়ে আসা হয়। কোথাও কোথাও বরকে স্নান করানোর রীতি প্রচলিত আছে। তারপর মন্ডপের সামনে নিয়ে আসা হয়। এই সময় কনের বাপ এবং বরের সামনেই ব্রাহ্মণের মন্ত্র উচ্চারণের মধ্য দিয়ে গোত্রান্তরের কাজটি সম্পন্ন করেন।

সাতপাক ও শুভদৃষ্টি

লাল বেনারসি শাড়ি এবং সোনার অলংকার দিয়ে সুন্দর করে সাজানো কনেকে জামাইবাবু কোলে করে নিয়ে আসে মন্ডপে। বর-কনে দুজনকে দুটি পিঁড়িতে মুখোমুখি দাঁড় করানো হয়। দুই পক্ষের বৈরাতি একটি নতুন বিছানার চাদর (পান্না) দুজনের মাঝখানে ধরে রাখে। বর-কনের হাতে খই তুলে দেয় কনে ছোট ভাই। এর জন্য তাকে বস্ত্রদান করে পাত্রপক্ষ। কনে খই নিয়ে পিঁড়ির উপর একপাক ঘুরে সেই খই বরের পায়ে দেয়। বর খই নিয়ে একপাক ঘুরে সেই খই কনের মাথায় দেয়। এইভাবে সাতবার **প্র**দক্ষিণ করতে হয় তবে বর-কনে সাতপাকে বাঁধা পড়ে। এরপর সেই পান্না বৈরাতি এবং জামাই বাবু বর-কনের মাথার উপর ধরে রাখে চাদর ঢাকা অবস্থায় বর-কনের শুভদৃষ্টি সম্পন্ন হয়। কনের বোন বরের পাছরা এবং কনের ওড়নার শেষ প্রান্ত নিয়ে লগন গিঁটো বেঁধে দেয়।

সম্প্রদান

কনের পিতা থালাবাসন, কাঁসার হাড়ি, জগ, বাটা আর নানা আসবাবপত্র জামাইয়ের হাতে সম্প্রদান করেন। তারপর একটি কাঁসার গ্লাসে কলার খোলে বরের হাতের উপর মেয়ের হাত রেখে সুতো বা কাশ দিয়ে বেঁধে দিয়ে জামাইয়ের হাতে মেয়ে সম্প্রদান করেন। সম্প্রদানের পর মেয়ে অন্য গোত্রে চলে যায়।

পানিছিটা ও মিতর ধরা

বিবাহের আসরে ব্রাহ্মণের মন্ত্র উচ্চারণের মধ্য দিয়ে কোন বয়স্ক মহিলা বা পুরুষ আমের পল্লব দিয়ে ঘটের জল বর-কনের মাথায় ছিটিয়ে দিয়ে নতুন সম্পর্ক স্থাপন করে। তাদের বলে পানিছিটা বাপ ও মাও। আবার বন্ধু স্থানীয় কেউ একইভাবে জল ছিটিয়ে মিতর (মিত্র) ধরে। এই দুই নতুন সম্পর্কের লোক পরিবারের সঙ্গে আত্মীয়তার বন্ধনে আবদ্ধ হয়। এমনকি মারা গেলে মৃত্যুশৌচ পালন করতে হয়।

গৌরবচন

নাপিত বিবাহ শেষে গৌরবচন পাঠ করে বিবাহ সুসম্পন্ন করে। গৌরবচন হল হরগৌরীর বিবাহ সম্পর্কিত স্তোত্র পাঠ।

দান দেওয়া

বিবাহ শেষ হলে বিয়ের আসরে দান দেওয়া অর্থাৎ আশীর্বাদসূচক দানসামগ্রী প্রদান করার রীতি প্রচলিত আছে। কাঁসার বাসন, টাকা এমনকি গরু দান দেওয়ার প্রচলন আছে। একটি কাঁসার গ্লাসে উপর লাল শালুতে বর হাত রাখে তার উপর কনে হাত রাখে। তারপর একে একে দানসামগ্রী দেওয়া শুরু হয়। বয়সে বড় হলে দান দিয়ে বর-কনেকে ধান দূর্বা দিয়ে আশীর্বাদ করেন। বর-কনে একসাথে মাথা নামিয়ে প্রণাম করে। ছোট হলে দান দিয়ে বর-কনেকেই প্রণাম করে। পাশে বসেন জামাই বাবু সে দানসামগ্রী গুছিয়ে রাখে। এরপর থাকে কড়ি খেলা, খিলিপান খেলা, চাইলন বদল, প্রভৃতি আচারগুলি বৈরাতি করে থাকে। বর-কনে বিবাহ অনুষ্ঠানে উপস্থিত বয়স্কদের প্রণাম করে আশীর্বাদ নেয়। তারপর বৈরাতি তাদের উত্তর ঘরে নিয়ে যায়। কনের বোনেরা দরজা বন্ধ করে (কোয়ারি) দেয়। বরের বাড়ির থেকে ঘরে প্রবেশের নির্ধারিত অর্থ পেলে দরজা খুলে দেয়। গোটা অনুষ্ঠানটি আনন্দ-বেদনা, হাসি-ঠাট্টায় মিলেমিশে একাকার হয়ে যায়।

বিদায় পর্ব

কন্যা বিদায়ের সময় করুণ সুরে সানাই বাজে, সেই সুরে সকলের চোখে অশ্রুভারাক্রান্ত হয়ে ওঠে। মায়ের কোলে কন্যাকে বসনো হয়। মা কান্নায় ভেঙে পরে কিছুতেই মেয়েকে ছাড়তে চায় না। কন্যার জামাইবাবু কোলে নিয়ে কনেকে গরু গাড়িতে তুলে দেয়। এখন সুন্দর করে সাজানো টেক্সিতে চড়ে বর আসে সেই টেক্সিতে কনেকে তুলে দেওয়া হয়। বর একটি শাড়ি কন্যার মায়ের হাতে দিয়ে প্রণাম করে গাড়িতে গিয়ে বসে। সানাইয়ে বাজতে থাকে একটার পর একটা করুণ গানের সুর-'বাচ্চা থাকি পুষিনু ময়না দুধ ভাত দিয়া/ যাবার বেলা গেলু ময়না বুকে শেল দিয়া।' কনেকে একা বরের বাড়ি পাঠানো হয় না, সঙ্গে যায় আগরাটুকি বুড়ি বা দানী

বুড়ি (ইনি অবশ্য কনের দিদিমা বা ঠাকুমা হবেন) আর দুইজন বোন। নতুন পরিবেশে কনেকে যাবতীয় কাজকর্ম শেখায় এবং সাহায্য করে।

বিবাহ পরবর্তী লোকাচার

বরণ ও বাসি বিয়ে

বরযাত্রী যখন ফিরে আসে তখন রাত প্রভাত হয়। বরের মা বরণডালা সাজিয়ে পুত্র ও পুত্রবধূকে বরণ করে বাড়ির ভিতর নিয়ে আসে। বৈরাতি তুলসীতলায় বর-কনেকে বসায় সেখানে দান দেওয়া পর্বটি চলে। দান দেওয়া শেষ হলে শুরু হয় কড়ি খেলা এবং আংটি খেলা। সেখান থেকে কনেকে নিয়ে যাওয়া হয় উত্তর ঘরে। সেই সময় মেয়ের অধিবাসের শাড়িটি উঠান থেকে ঘরের দরজা পর্যন্ত বিছিয়ে দেওয়া হয়। তার নিচে নির্দিষ্ট দূরত্বে একটি করে মোট পাঁচটি মাটির প্রদীপ দেওয়া হয়। উত্তর ঘরে প্রবেশের সময় কনে আগে আগে প্রতিটি দেওয়ারি(মাটির প্রদীপ) পা দিয়ে স্পর্শ করে যাবে আর বর পা দিয়ে গুড়িয়ে দেবে। বিশ্বাস এই মাটির প্রদীপ যত টুকরো হবে তত সন্তান সন্ততিতে ঘর ভরে যাবে। সেই সময় বরের বোনেরা দুয়ার ধরে টাকা দাবী করে ছড়া কাটে-

ইচিং বিচিং চিচিং চা
ধইসু দাদা দুয়ার টা ।।
পাঁচশো টাকা নিমো।
দুয়ার ছাড়ি দিমো।।
একশো টাকা নিবো না।
দুয়ার ছাড়ি দিবো না।। [৫]

যে টাকা দাবী করে তা পেলে দরজা খুলে বর কনেকে ভিতরে প্রবেশ করতে দেয়। সেখান থেকে কনেকে নিয়ে যাওয়া হয় গোয়াল ঘরে গোবর ফেলার জন্য, একটি ঝুড়িতে গোবর নিয়ে মাঠে ফেলে দিয়ে আসে। সেখান থেকে এসে একটি এক টাকার কয়েন শাশুড়ির হাতে দেয়। উঠোন ঝাড় দেওয়া, রান্না ঘর মোছানো প্রচলিত রীতি নতুন বধূকে দিয়ে করানো হয়। তারপর খনন করা পুকুরের পারে দুটি পিঁড়িতে দুইজনকে একসাথে বসানো হয়। বৈরাতি দুইজনের গায়ে কুর হলুদবাটা ভালো করে মাখায় এবং স্নান করায়। এইভাবে বাসি বিয়ের মধ্যে দিয়ে সমগ্র বিবাহ পর্ব সমাপ্ত হয়।

সিদ্ধান্ত

পরিশেষে বলা যায়, রাজবংশী সমাজের বিয়ে মানেই লৌকিক আড়ম্বরপূর্ণ একটি সামাজিক অনুষ্ঠান। শাস্ত্রীয় মাঙ্গলিক অনুষ্ঠানের পাশাপাশি কৌমসংস্কৃতি উপকরণ, উর্বরাতন্ত্র ও প্রজনন ক্রিয়ার প্রতীকী ব্যবহার, আমোদ-বিনোদন প্রিয় জীবনচর্যা, সম্মিলিত সমন্বয় ভাবনা সবকিছুর আধার এই বিয়ে। নাচে গানে নিয়মে-আচারে এমনকি মনন ভাবনায় এক নিজস্ব এবং স্বতন্ত্র ধারা আজ রাজবংশী সমাজের বিয়েতে দেখা যায়। যতই যন্ত্রায়ণের যুগ আসুক, যতই সমাজ পরিবর্তন হোক বিবাহের এই লোকাচারগুলি পরম্পরাগত ভাবে চলতে থাকবে। একটি জাতির ঐতিহ্য ও কৃষ্টির পরিচয় বাহক এই লোকাচারগুলি লোকসংস্কৃতির অন্যতম উপাদান।

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Research Article

Herbal Abeer or Gulal Preparation from Flowers and Vegetables

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Abstract: Herbal abeer or Gulal is traditional powder used in various cultural and religious ceremonies, have attracted attention due to their eco-friendly and skin-friendly properties. This study explores the preparation of herbal abeer using vegetables / flower extracts, focusing on their sustainable production and potential applications. The process of making abeer, is discussed in detail from various flower species like marigold, bougainvillea, rose, Asian pigeonwings and vegetables like spinach, Malabar spinach (pue), turmeric and beetroot. Natural binding agents such as arrowroot/soap stone powder or talcum powder have been used for their effectiveness in the formulation of cohesive powder. The resulting herbal abeer formulations are analyzed for colour stability, skin compatibility and shelf-life. Furthermore, the environmental impact of artificial colour used in commercial abeer production has been compared with herbal alternatives. After all, it has been said about why we should use herbal abeer instead of synthetic abeer. The main purpose of discussing about making organic Holi colours is that people can get a good knowledge about the nature of organic colours and can easily make them at home.

Keywords: Natural dye, gulal, Vegetables and Flowers, Natural Use of Colours, Abeer, Holi colour

Introduction

Herbal Abeer holds a significant place in various cultural celebrations, serving as a symbol of joy, renewal, and communal harmony[1]. Traditionally crafted from natural ingredients, these coloured powders add a splash of vibrancy to festivities such as Holi, weddings, and religious ceremonies [2]. As we all know nowadays people want to use natural colours due to anti-allergic activity and other benefits[1]. Herbal abeer from flowers and vegetables offers a harmonious fusion of tradition and innovation[3]. By harnessing the natural pigments found in plants, we honour old-age customs while embracing eco-friendly practices. This sustainable approach not only enhances the vibrancy of festive celebrations but also deepens our connection to the natural world[4]. A few publications on the vegetable dyes from India and some state specific reports from West Bengal, Manipur, Arunachal Pradesh, Uttarakhand and others have generated a fresh interest on this aspect[1,3,5,7-9]. From marigold petals to spinach leaves, each plant contributes thiers's unique colour and properties to the art of making herbal abeer. By blending tradition with modern sensibilities, we pave the way towards greater environmental consciousness and cultural appreciation[9]. Our journey into the realm of herbs begins with an exploration of botanical diversity, as we gather flowers and vegetables to serve as the base for our pigments. Marigold, rose, bougainvillea petals, Asian pigeonwings, sacred petals, turmeric, beetroot,

Spinach and Malabar spinach leaves, create a vibrant palette from which we draw inspiration, each of which is full of unique colour and characteristics. Through careful selection and preparation, we aim to distill the essence of this botanical treasure into a truly enchanting powder. With our botanical bounty in hand, we begin the delicate process of transforming petals and leaves into a fine powder, paying homage to ancient techniques passed down through generations. Grinding, mixing and casting become acts of reverence as we blend tradition with innovation, experimenting with different proportions and combinations to achieve the perfect balance of colour and texture. Through every step of the preparation process, we respect the rich cultural heritage embodied by Herbal Abeer, while embracing modern practices of sustainability and eco-consciousness. No matter how appealing synthetic colours may appear, prioritizing their quality is essential to avoid potential health issues[10]. Embracing natural or organic holi colours enhances the fun and safety of this ancient festival of colours. These herbal hues, derived from fruits, leaves, stems, and flowers, are not only skin-friendly but also environmentally harmless [11]. Their gentle nature ensures they are as easy on clothes as they are on the skin, washing off effortlessly while safeguarding hair and skin[10]. Organic Holi colours boast key features like being non-toxic, super skin-friendly, free from heavy metals, and easy to remove[11]. Crafting colours at home using household ingredients has been a prevalent practice in Hindu tradition, offering a safe and enjoyable celebration[12].

Materials & Methods

Materials for Herbal Abeer are

1. Fresh flowers: Marigold (Ganda), Asian pigeonwings (Aparajita), sacred (Palash), Bougainvillea, Rose

2. Vegetables: Spinach (Palong), Malabar spinach (Pue), Beetroot and Turmeric (Holud).

3. Base: Arrowroot flour/Soap-stone powder or Talcum powder (we preferred soap-stone / talcum powder for their fineness)

The materials were 1st washed in water and were dipped in minimum amount of luke warm water for overnight. Then the wet materials were crushed in the grinder. The paste formed is transferred to the sieve to get rid of the granular portions. This paste was then mixed with soap-stone powder and spread on a plastic sheet and left under fan to dry at room temperature. Exposure to sun is restricted as it may be decolorized. When dried lumps were formed, these were again grinded to get a dried free flow powder. Lemon essence along with Jasmine was mixed with the floral powder and Lemon with rose was mixed to the rhizome and leaf powder. 3ml of Lemon + 10ml of Jasmine/Rose essence were mixed with 1 Kg of the powder. Final powder products were air dried and packed in zipper packets.

Picture : 1 (Petals Of Different Flowers)

Result & Discussion

By following the above methods, we have been able to make of different colours i.e. yellow from marigold flower petals, orange peel and turmeric, yellowish brown from sacred, blue from Asian pigeonwings, green from leaves and red & pink from bougainvillea, rose & beetroot respectively. This work demonstrates the preparation of organic Holi colour. Colours from fruits, vegetables and flowers provide good natural substances and have no harmful effects [4]**.** The specialty of organic colour is that we can use it for our Holi festival. It is also appropriately used in rangolis made in different festivals of Indian tradition [3]. It is not harmful in any way and is a very useful and safe option for women and children [11]. We could start a conversation about the resurgence of herbal remedies in modern wellness culture, where we will discuss how herbal abeer return to natural healing practices and rejection of synthetic alternatives. Artificial Holi colours contain various harmful substances such as heavy metals like lead, mercury, chromium and copper. These substances can cause long-term health problems such as skin allergies, irritation and in severe cases, cancer[10]. Additionally, the synthetic colours contain toxic chemicals that can harm both humans and the environment, so we should never use artificial colours and raise awareness about them.

Herbal abeer were sometimes seen to be spoiled due to fungal activity if the final products (when arrowroot powder used as binder) not proper sealed, this problems were overcome by using soap-stone powder and telecom power. We have noticed here that using soap-stone powder was cost effective than telecom powder. All extracts of present study materials have anti-microbial/antifungal/pharmaceutical activities, those we will have to study in details.

Recognized for their harmlessness, organic colours pose no threat to our body even if ingested accidentally, making them a preferred choice for all occasions. By utilizing natural materials, organic colours contribute to environmental friendliness and raise awareness about the benefits of organic living [13]. As the importance of eco-friendly and chemical-free colours gains attraction, the negative impacts of synthetic colours on the environment and human health are being emphasized [10]. By opting for organic hues, we not only prevent severe diseases like skin cancer and eye problems but also preserve traditions and deepen our connection with nature [11]. By engaging with these thought-provoking discussions and hashtags on social media, we could build a vibrant online community passionate about herbalism and holistic health, inspiring others to embrace natural remedies and holistic living.

Picture : 2 (Abeer making process made from marigold flowers)

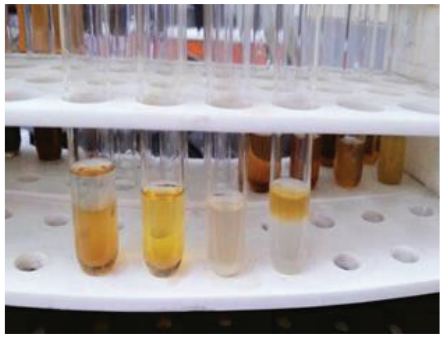
Picture : 3 (Talcum powder is added to spinach juice)

Picture : 4 (Abeer made from beetroot left to dry in the Sun)

Sl no	Phytochemical tests	Beet root	Merigold	Bogenvellia	Polash	Termaric	Spinach	pue
1	Tannin	-	-	-	+	+	+	+
2	Phenols	+	+	+	+	+	+	+
3	Flavonoid	+	+	+	+	+	+	+
4	Coumarine	+	+	-	+	+	-	-
5	Saponin	+	+	+	+	-	+	+
6	Anthocyanin	+	+	+	+	-	-	-
7	Betacyanin	+	-	+	+	-	-	-
8	Glycoside	-	+	+	+	+	+	+
9	Quinine	+	-	-	+	+	+	+
10	Steroid	+	-	+	-	-	+	+

Table 1. Different colour extracts of different plants were studied for phytochemical constituents

The phytochemical analysis showed that colour extract from studied samples contain some secondary metabolites. The table.1 shows the presence (+) and absence of (-) of phytochemical constituents in the tested samples. In this analysis we obtain the presence of saponin, quinone, flavonoid, phenols, coumarin, steroid, anthocyanin and betacyanin, and the absence of tannin and glycoside in beet root, Polash contain all studied chemicals except steroid, all colour extract contained phenols and flavonoids (picture 5). Secondary metabolites present in plants which is responsible for their therapeutic activity[15].



Picture: 5 (Presence of Phytochemicals)

Picture : 6 (Our final products - Herbal abeer)

Conclusions

Holi festival is famous and popular all over India. After Holi, we see that the colour always remains on our hands for three-four days because artificial colour does not rinse off easily. It causes itching in our skin and various types of skin related problems arise [10]. Our organic Holi colours could solve these. They are made from natural food items, they are not harmful for our skin and for our health [12]. We find that various types of toxic elements are found in artificial Holi colours which cause blindness if they go into our eyes and much more than this. We should not buy goods blindly and the demand for herbal abeer is increasing day by day. People are more inclined towards herbal products than chemical ones. People who are involved in this business are becoming profitable. If the demand for herbal abeer is increasing with every passing year, more people can get employment. There is another aspect of Holi that women are also be involved in the work (if they trained well) of home industry and hundreds of women are independent, financially.

In conclusion, crafting Herbal Abeer from flowers and vegetables offers a delightful blend of tradition, creativity, and sustainability [12]. By harnessing the natural pigments found in plants, we honour cultural heritage while minimizing our environmental impact [16]. This eco-friendly approach not only adds vibrancy to festivities but also fosters a deeper connection to the beauty and abundance of the natural world [14]. We continue to explore the art of Herbal abeer preparation, let's celebrate the colourful stage of life and joy; it brings to our hearts and communities.

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Research Article

Measuring Allocation of Healthcare Resources by PCA in Indian Sundarban

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Abstract: Proper healthcare resource allocation is a global concern. We have embraced a comprehensive method method for measuring the allocation of healthcare resources through the Composite Healthcare Resource Density Index (CHRDI). Principal Component Analysis (PCA) is an efficient and reliable quantitative method for computing composite score. We categorize Indian Sundarban in peripheral and non-peripheral blocks based on socioeconomic and environmental vulnerability. The peripheral blocks maintain a direct coastline with the Bay of Bengal or are adjacent to the reserved forest. The allocation of healthcare resources of nineteen blocks of Indian Sundarban have measured and ranked. The PCA-based CHRDI can adequately clarify the differences in the feasibility of the allocation of healthcare resources between the blocks and strength and weaknesses of each block. Additionally, it may facilitate local governments in implementing any policy or project more conveniently for properly allocating healthcare resources in the study area.

Keywords: Healthcare resource allocation; Comprehensive method; PCA; Composite Healthcare Resource Density Index

Introduction

Human health is a crucial component of socioeconomic progress It is difficult to overlook the importance of human healthcare [1]. According to empirical studies, a lack of healthcare facilities in developed and developing countries increases avoidable deaths [2]. Proper distribution of healthcare resources can improve various health indices such as life expectancy, crude birth rate, death rate, infant mortality rate, maternal mortality rate, disease incidence, and so on [3]. There is a reasonable correlation between health, healthcare infrastructure, and economic growth and the spread of healthcare facilities can improve long-term development [4]. As a result, allocating healthcare resources is essential for achieving 'Health for All' [5]. Equal distribution of healthcare services is one of the most critical requirements for establishing population health equity. Everyone should have equitable access to healthcare services, with allocation based on local

requirements [6]. Equity, utility, and efficiency are the most critical components in allocating healthcare resources [7].

1 Specific Problem to Study

Healthcare is integral to one's well-being [8]. Inequitable healthcare resource distribution and a lower budget priority for healthcare are the two major roadblocks to universal healthcare coverage [9]. Spatial thinking and study have become increasingly popular in numerous academic topics [10]. The majority were macro-level research focused on a specific topic or factor [11]. Several studies have looked at the spatial disparities in healthcare resources in India, although most were at the macro level [12]. There is scarcity of research to examine the healthcare resources in micro-level. The goal of this study is to construct a composite index for measuring the allocation of healthcare resources in Indian Sundarban.

2 Materials & Methods

2.1 Study Area

UNESCO designated the Sundarban (India and Bangladesh) declared as a World Heritage Site on December 7, 1997, because of its unique biodiversity [13]. This region is particularly vulnerable to different coastal hazards and tragedies due to global climate change and the resulting rise in sea level [14]. The present work has focused on the Indian Sundarban consists of 19 blocks. We divide the study area into two sections based on socioeconomic and environmental risk: peripheral and non-peripheral. The periphery has a direct line of sight to the Bay of Bengal or the protected forest. Gosaba, Basanti, Kultali, Sagar, Patharpratima, Namkhana, and Hingalganj are the seven blocks that make up the peripheral area. The non-peripheral site consists of the remaining twelve blocks. This region does not have direct access to the Bay of Bengal, nor is it next to the Sundarbans' protected forest.

2.2 Data Sources and Selected Indicators

Table 1: Selected Indicators for Healthcare Resource Allocation

Serial No.	Abbreviation	Description	Source
1	HI	Total Government running Healthcare Institutions	Census of India (2001 & 2011)
2	HI1	Government Hospital including Rural Hospital	
3	HI2	Primary Health Centre (PHC) & Block Primary Health Centre (BPHC)	
4	HI3	Private Hospital & Nursing Home (Including N.G.O running Hospital)	
5	HI4	Public Health Sub centre (PHS)	
6	HI5	Family Welfare Centre (FWC)	
7	HI6	T.B. Clinic	
8	D	Total Doctors	
9	D1	Doctors in Government running Institutions	
10	D2	Registered Medical Practitioner (RMP)	
11	D3	Doctors without conventional degree	
12	B	Number of Beds (Government running Institutions)	

The present work totally based on secondary sources of data. We extract data from the North and South 24 Paragana District Census Handbooks and District Statistical Handbooks for 2001 and 2011. Various reporting activities are constructive in determining the indicators, and associated papers serve as credible sources of references [15]. There are no widely accepted indicators for evaluating the allocation of healthcare resources. The criteria should be policy-relevant, quantifiable, analytical, and capable of providing policymakers and other target audiences with practical, concise, and accurate information in an easy-to-understand style [16].

For evaluating the allocation of healthcare resources, we select twelve fundamental healthcare indicators and divide them into three sets (Healthcare Institutions, Doctors and Beds). Table 1 provides thorough information regarding selected indicators for the entire study.

2.3Building up Composite Healthcare Resource Density Index (CHRDI)

For measuring the overall status of health resource allocation for each block of Sundarban, we compute Composite Healthcare Resource Density Index (CHRDI). The construction of CHRDI follows three steps.

Computation of HRD

At first, we calculate Healthcare Resource Density (HRD). The HRD maintains the impact of inhabitants and geographical components on the accumulation of health resources but escaping bias occurred by single inhabitants or geographical traits. We applied the following equation (1) to estimate HRD.

$$HRD_{ij} = \frac{HR_{ij}}{\sqrt{A_j P_j}} \qquad (1)$$

HRD_{ij}: The Healthcare Resource Density for i^{th} healthcare resource of the j^{th} region

HR_{ij}: Quantity of i^{th} healthcare resource of the j^{th} region

A_j: Geographical area of the j^{th} region

P_j: Population of the j^{th} region

Standardization of HRD

As an initial step for developing an index, standardization is indispensable. The process of standardization can transform the data set into identical measures. For data standardization, we applied the following equation (2).

$$SHRD_{ij} = \frac{HRD_{ij} - \underline{HRD_i}}{\sigma HRD_i} \qquad (2)$$

$SHRD_{ij}$: Standardized Healthcare Resource Density for i^{th} health resource of the j^{th} region

HRD_{ij}: The Healthcare Resource Density for i^{th} health resource of the j^{th} region

$\underline{HRD_i}$: Mean value of HRD of i^{th} health resource

σHRD_i: Standard deviation of HRD of i^{th} health resource

Composite Healthcare Resource Density Index (CHRDI)

For measuring CHRDI, we have computed Principal Component Analysis (PCA). It is essential to evaluate whether the data set is apt for carrying out the PCA. We determine the Kaiser–Meyer–Olkin (KMO) assessment of sampling adequacy [17]. Kaiser–Meyer Olkin (KMO) statistics help evaluate the association strength among variables. We execute Principal Component Analysis with seven fundamental healthcare resource variables [HI1, HI3, HI4, HI5, HI6, D & B (KMO value, 0.562)]. For measuring composite score PCA is a well-known method [18]. For measuring the CHRDI, we have applied equation no. 3. The retained quantity of components determines to explicate at least 80% variance of the data.

$$CHRDI_j = \sum_{p=1}^{q} \sum_{i=1}^{m} \frac{e_{pi}}{\sqrt{\lambda_p}} SHRD_{ij}\, \beta_p \qquad (3)$$

$CHRDI_j$: Composite Healthcare Resource Density Index of the j^{th} region

$SHRD_{ij}$: Standardized Healthcare Resource Density for i^{th} healthcare resource of the j^{th} region

e_{pi}: Factor loadings of the i^{th} indicator for p^{th} principal component

λ_p: Eigenvalue of p^{th} principal component

β_p: Variance explained by the p^{th} principal component

3 Results

CHRDI provides a comprehensive idea regarding block-wise healthcare resource allocation of Indian Sundarban. Table 2 represents the analysed results, including eigenvalues, factor loadings, and accumulation of variance of correlated variables. Four principal components explain more than 80% of the overall variance of the data.

In 2001, the first principal components accounted for 34.72% of the total variance. PC1 was significantly associated with the availability of doctors (0.504) and beds (0.413). The second component had a notable correlation with private healthcare organizations (0.472) and government-running healthcare institutions providing inpatient care (-0.668). PC3 remarkably correlated with Public Health Sub centre (0.550), Family Welfare Centre (0.633), and T.B clinic (0.433).

Table 2: PCA Results on Health Resource Density Indicators

PC Retained	2001				2011			
	PC1	**PC2**	**PC3**	**PC4**	**PC1**	**PC2**	**PC3**	**PC4**
Eigen Values	2.431	1.605	1.092	0.684	2.91323	1.85545	0.73121	0.56964
Variance Explained (%)	34.72	22.92	15.60	9.78	41.62	26.51	10.45	8.14
Cumulative (%)	34.72	57.64	73.24	83.02	41.62	68.13	78.58	86.72
Indicators	**Factor Loadings**				**Factor Loadings**			
D	0.504	-0.047	-0.298	-0.026	0.502	0.029	-0.221	-0.055
HI3	0.463	0.472	0.046	0.035	0.499	-0.016	0.236	0.436
HI4	0.302	-0.253	0.550	0.668	0.364	0.255	0.500	-0.726
HI5	0.278	-0.150	0.633	-0.701	-0.208	0.588	-0.009	0.136
HI6	-0.402	0.298	0.433	0.192	0.049	0.612	-0.564	-0.148
B	0.413	0.391	-0.040	0.123	0.475	0.241	0.027	0.406
HI1	0.177	-0.668	-0.127	0.089	-0.308	0.395	0.572	0.271

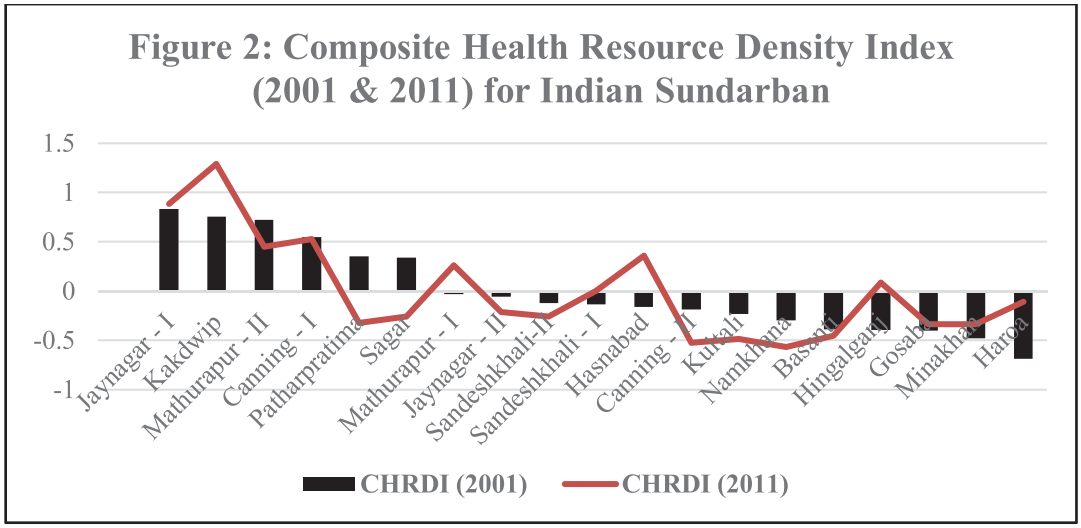
In 2011, the first principal components explained 41.62% of the total variance. PC1 was significantly associated with the availability of doctors (0.502), private hospitals (0.499), and beds (0.475). The second component (PC2) had a notable correlation with Family Welfare Centre (0.588) and T.B clinic (0.612). PC3 was remarkably correlated with Public Health Sub-centre (0.5) and government-running healthcare institutions providing inpatient care (0.572).

We have computed Composite Health Resource Density Index (CHRDI) for each block of Sundarban with the help of PCA. Table 3 represents the results of CHRDI and the benchmark ranking of each block of Sundarban for 2001 and 2011. Figure 1 represent the block-wise CHRDI for the years of 2001 and 2011. In 2001, Jaynagar-I attained the best situation with CHRDI 0.833 while Haroa (-0.685) received the lowest score. Kakdwip, Mathurapur-II, and Canning-I acknowledged second, third, and fourth ranks, respectively. Hingalganj, Gosaba, and Minakhan were in 16th, 17th, and 18th positions. In 2011, Kakdwip (1.291) was in the

best position. It follows Jaynagar-I, Canning-I, and Mathurapur-II, ranking second, third, and fourth spots. Namkhana (-0.567), on the other hand, is the worst performing block in health resource allocation. Basanti, Kultali, and Canning-II are in 16th, 17th, and 18th positions, revealing a frightening scenario in this perspective.

Table 3: Block-Wise Composite Health Resource Density Index (2001 &2011) for Indian Sundarban

BLOCK NAME	2001		BLOCK NAME	2011	
	CHRDI	RANK		CHRDI	RANK
Jaynagar - I	0.833	1	Jaynagar - I	0.889	2
Kakdwip	0.754	2	Kakdwip	1.291	1
Mathurapur - II	0.723	3	Mathurapur - II	0.448	4
Canning - I	0.549	4	Canning - I	0.528	3
Patharpratima	0.355	5	Patharpratima	-0.324	12
Sagar	0.339	6	Sagar	-0.259	11
Mathurapur - I	-0.028	7	Mathurapur - I	0.262	5
Jaynagar - II	-0.056	8	Jaynagar - II	-0.211	9
Sandeshkhali-II	-0.121	9	Sandeshkhali-II	-0.256	10
Sandeshkhali - I	-0.132	10	Sandeshkhali - I	0.001	7
Hasnabad	-0.162	11	Hasnabad	0.357	15
Canning - II	-0.187	12	Canning - II	-0.527	18
Kultali	-0.23	13	Kultali	-0.487	17
Namkhana	-0.296	14	Namkhana	-0.567	19
Basanti	-0.387	15	Basanti	-0.454	16
Hingalganj	-0.393	16	Hingalganj	0.085	6
Gosaba	-0.399	17	Gosaba	-0.333	13
Minakhan	-0.476	18	Minakhan	-0.337	14
Haroa	-0.685	19	Haroa	-0.107	8



4 Discussions

This PCA-based Composite Healthcare Resource Density Index (CHRDI) can convert major healthcare resource indicators into a single score to measure and assess the allocation of healthcare resources. It can quantitatively explain the overall status of the healthcare resources of every block of Indian Sundarban. CHRDI can adequately clarify the differences in the viability of healthcare resources between the blocks, but it can also identify the strength and weaknesses of each block. Thus, potential improvement requirements may be suggested by studying CHRDI and as well as each indicator also. This index may be positive or negative. The highest positive value indicates maximum attainment towards healthcare resources, and the highest negative value denotes vulnerability in healthcare resource achievement.

Table 3 illustrates block-wise overall performances of healthcare resources and the benchmark ranking results. Figure 2 and 3 represent Composite Healthcare Resource Density Index for the year 2001 and 2011 respectively. Substantial spatial variations exist in the allocation of healthcare resources in Sundarban. However, there is a tendency for progress in an imperceptible way. In 2001, 13 blocks achieved a negative composite score; in 2011, 11 blocks had a negative composite score. Based on the decadal performances, we can divide all the blocks into two segments, i.e., progressive (improving rank) and non-progressive (fail to improve rank). Nine blocks (Canning-I, Mathurapur-I, Kakdwip, Sandeshkhali-I, Hasanabad, Haroa, Minakhan, Gosaba, Hingalganj) have improved their ranks (2001 to 2011). Among these nine blocks, three blocks (Hasanabad, Haroa, and Hingalganj) have performed remarkably well by enhancing their positions drastically. The remaining ten blocks fail to uplift their positions regarding healthcare resources. Canning-II, Kultali, Sagar, Namkhana,

and Patharpratima have shown very disappointing performances by dropping their previous situations radically**.** In 2011, Namkhana is the worst performing block in health resources with CHRDI -0.567. We elaborate in Table 2 that PC1 accounts for more than 40% of the total variance and has a striking association with doctors, beds, and private hospitals. Therefore, this is evident that Namkhana had acute drawbacks in these three aspects (Doctors, private organizations, and beds), and immediate actions should be adopted to recover the situation.

In 2001, two blocks from the peripheral region [Sagar (fifth position) and Patharpratima (sixth position)] achieved relatively better positions in CHRDI. However, in 2011, only one block (Hingalganj) snatched a comparatively superior position (7^{th} rank). Out of seven blocks, just two blocks experienced advancements in Composite Health Resource Density, and the rest of them failed to better their condition in healthcare resources. As a result, there was homogeneity in allocation in the peripheral region, but most of them became backbenchers in healthcare resource allocation.

Conclusion

This study provides a comprehensive approach by applying PCA based Composite Healthcare Resource Density Index (CHRDI) for evaluating the status of healthcare resource allocation in Indian Sundarban. CHRDI reflects the overall status of healthcare resources at the micro-level. Due to unfavourable terrain and environment, this region have a poor developed transportation system. Here, transportation is a costly and time-taking process. As a result, all the healthcare resources must be allocated according to area and population. The composite Healthcare Resource Density Index identifies a consistent estimation of the distribution of healthcare resources by considering all facts provided by indicators. It can quantitatively explain the overall status of the healthcare resources of every block of Indian Sundarban. CHRDI can adequately clarify the differences in the viability of healthcare resources between the blocks, and it can identify the strength and weaknesses of each block**.** Thus, it may facilitate local governments in implementing any policy or project more conveniently for properly allocating healthcare resources in the study area.

In this study, however, there are few restrictions. We cannot incorporate various healthcare resource indicators due to the inaccessibility of reliable data. In a way, due to the unavailability of primary data the entire work depends on secondary data. This limitation

outshined by the next researchers working in the same field of study, offering them new arena of research in future**.**

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Review Article

Urban and Peri-urban Agriculture as a Sustainable Solution to Urban Environmental Crisis: A Review

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Abstract: This review highlights the significance of UPA as a local ecosystem service. The methodological approach comprise a systematic literature search and an explanatory review of books and journal articles. According to the review, urban and peri-urban agriculture is essential for preserving ecology and biodiversity, mitigating natural disasters, and combating climate change in urban areas. If managed well, agricultural lands could act as an essential buffer between environmental sustainability and urban development. In this context it is recommend that all cities create an urban agricultural management policy to support urban and peri-urban agriculture to make it a competent urban landuse.

Keywords: Urbanisation, Subsistence farming, Sustainable cityscape,

Introduction

Extension of urban areas is an inevitable consequence of socio-economic development and exerts its own set of negative effects upon society and the surrounding natural resources [1]. This exaggerated pace of urbanisation poses numerous challenges for urban dwellers, including air and water pollution, waste management and climate change [2 - 4]. Developing urban and peri urban agriculture (UPA) has been identified as a possible way to deal with these issues while also benefiting the local economy, environment, and society [5, 6]. From an eco-environmental perspective, UPA is also viewed as an important strategy which may help to achieve three of the important SDGs (viz., SDG 11, 12 and 13) which in due course will help to mitigate the negative impacts of urbanization on urban natural environment (Table 1) [7]. Therefore, for overall urban sustainability, sustainable management of these UPA areas should be of the utmost significance. This can only be achieved by exploring the multifunctional benefits that UPA has to offer. Since impact of UPA on the entire region is diverse and multi-dimensional therefore in this paper the author has tried to summarized one of the important dimension of UPA i.e., the eco-environmental benefits of UPA based on successful examples across the globe.

Table 1: Contribution of UPA to the Sustainable Development Goals

Goals		Explanation
Goal 11	Sustainable cities and communities	Through Green Design and Ecovillages using urban farms and reduced carbon footprint. Make cities and human settlements inclusive, safe, resilient and sustainable (SDG Target 11.3)
Goal 12	Responsible consumption and production	Reducing ecological footprint by efficiently growing produce with minimal waste or pollutants
Goal 13	Climate change	Reducing consumption of imported food. Space efficient whilst minimising damage to the environment and natural habitats

Source: Adopted from Nicholls *et al.* (2020)

1. Methods

Peer-reviewed articles, conference papers, and books chapters were searched from online database such as Elsevier, Google Scholar and Springer. The specific keywords used for searching include urban agriculture, urban farming, rooftop farm, community garden combined with environmental sustainability, climate change, urban flood, environmental services, biodiversity, and agro-tourism. At the initial stage a total of 357 works of literature were retrieved from the systematic search. After reading the abstracts, few sources were eliminated that were not in urban settings or not focused on environmental benefits of UPA or not clearly representing any empirical evidence. Finally, after critical reading of the entire paper the final list of literature was narrowed down to 48 sources (Fig 1).

2 Review results/synthesis

In addition to production function UPA offers a wide range of eco-environmental functions *e.g.,* creation of green space, micro-climate control, reduction of dust and pollutants, recycling of organic waste, contributing to biodiversity conservation combating climate change and urban flood etc. [2, 6, 8, 9]. These functions benefit the nearby community and society as a whole. These functions were systematically summarised in the following paragraphs.

2.1 Sustainability of urban environment and pollution control

The research by [10] illustrated that maintenance of air and water quality, nutrient cycling, soil formation and rehabilitation, carbon sequestration etc., were the important contributions of UPA areas which help in improving the urban environment. Moreover, these quasi-natural

landscapes were instrumental in increasing groundwater recharge [11]. In several cities of Netherlands, Germany and Slovenia organic farming techniques have been taken up as a part of UPA to control urban pollution [12]. In addition to lowering urban heat, urban vegetation, particularly trees, can act as potential carbon sequestration pools, reducing atmospheric carbon dioxide and enhancing air quality [13]. Some researchers made a notable observation that paddy fields adjacent to the city had the ability to contain flood water and acts as buffer to the city against the risks of flood [2, 12]. Agricultural activity plays a key role in soil formation and conservation by including key nutrients and organic matters in soil. Vegetable cultivation was reported to help in retaining soil erosion and helped to increase soil fertility through biological processes [14]. Appropriate land use combined with environmentally sound soil and water management practices could help to reduce the loss due to soil erosion. For example, an assessment of Ecosystem Services done on urban gardens in the city of Barcelona found out that prevention of soil erosion and maintenance of soil fertility were considered to be the most valued Ecosystem Service of UPA [16].

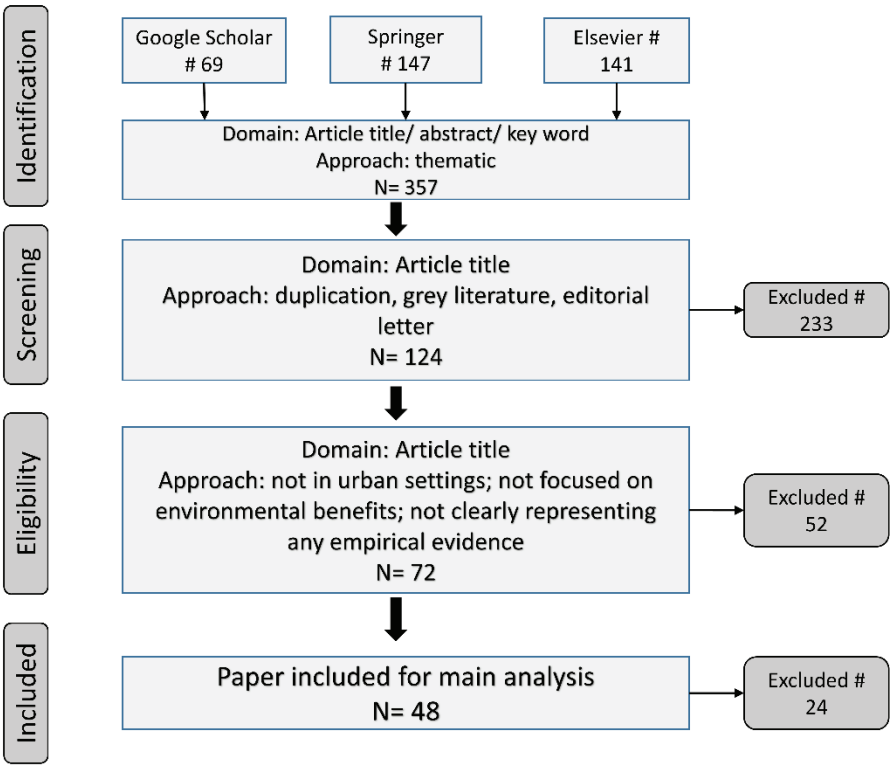

Fig 1: Schematic representation of the screening process

2.2 Combating climate change

It could be seen that living in cities was becoming more and more non-conducive due to change in climatic conditions and UPA could be a potential saviour in that scenario. Agriculture in the urban areas can provide environmental benefits not only by an environmentally friendly production process, but also reduce 'food miles' because of the close proximity of production and consumption centres [3, 16]. UPA increases the city's greenery by producing fresh foods close to the consumers, thus reducing energy used for transport which will positively impact the urban climate by reducing Greenhouse Gas emission [17].

Agroecosystems in and around urban areas could offer additional ecological benefits in modifying the urban micro-climate by mitigating the heat island effects [4, 18, 19]. In their study, [20] had observed that the large agricultural lots remained substantially cooler than the residential areas of a city in Australia on a mid-summer's day. As the number of extreme heat days increases under a changing climate, the importance of the cooling effect of UPA areas would increase in near future. Additionally, [21] had highlighted that an agrarian system had the capacity to act as a greenhouse gas sink and subsequently contribute to the improvement of the quality of air and regulate global climate change.

In addition to these beneficial effects of UPA, several researchers have also deduced that non-commercial, lower yield, land-intensive, open-air soil-based farms and gardens had the least influence from climate change [22]. Conversely, cutting-edge UPA techniques like hydroponics and aquaponics may produce more yields than traditional UPA while simultaneously having a greater impact on climate change. In case of modern and technology intensive UPA, two factors most responsible for climate change in indoor systems were energy usage and greenhouse structure [22]. While these factors undoubtedly contributed to improved yields, it appears that they were insufficient to offset their additional effects [22]. These results challenge the notion that UPA will significantly alter urban food systems by replacing food grown conventionally and mitigating the effects of climate change at the same time.

2.3 Urban waste management

UPA was also cited to have the potential to absorb and re-utilize many of the waste resources generated by cities which had recently become a serious concern for most of the urban authorities [20]. It was reported with the ability to turn the urban wastes into productive resources like compost production, vermiculture, irrigation with wastewater etc. [14]. In

many cities, local or municipal initiatives or systems exist to collect household wastes and organic trash from vegetable markets, agro-industries, etc. in order to produce compost or animal feed. There are various advantages in the production of compost such as, i) compost allows urban farmers to use fewer chemical fertilizers, ii) compost prevents problems related to the contamination of groundwater iii) compost-making process creates employment and provides income for the urban poor. A good majority of the households in urban as well as peri-urban areas of Kerala, who practice roof-top vegetable cultivation, opined that they could reduce household and kitchen waste through recycling [23].

In many cases, farmers use wastewater for irrigation in UPA areas [24, 25]. The use of wastewater for irrigation is not only advantageous for its high nutrient content, but it also facilitates year round production especially if there is lack of access to other sources of water for irrigation. In this regard, [26] had highlighted that, by re-using treated wastewater, both water pollution and scarcity of irrigation water in urban areas could be managed simultaneously. As in case of Gujarat, it was observed that small scale farmers preferred to irrigate their crops with wastewater as it was cheaper, more readily available and provides nutrients to the crops too [26]. Productive reuse of wastewater reduces the usage of fresh water for irrigation and reduces water pollution by preventing the discharge of wastewaters into surface water bodies. But the disadvantage is that without proper knowledge, the use of wastewater may lead to health and environmental problems. Pathogenic organisms in wastewater and excreta which are used in agriculture can cause several diseases [27, 28]. For example, a cholera outbreak in Jerusalem in 1970 was attributed to raw wastewater used in irrigation [29]. [30] highlighted that wastewater containing pathogens could contaminate crops directly through contact during irrigation or indirectly through contaminating the soil or through insects. Transmission of food-borne illness by pathogens due to irrigation with reclaimed water has been established for more than 100 years and accordingly irrigating crops, especially those eaten raw, with wastewater has been forbidden in some countries, such as Jordan [30]. [31] had found out that farmers suffered from skin diseases as they used polluted water downstream of Byramangala Lake in a case study from Bangalore. Likewise, higher rates of skin diseases, infectious diseases were seen among farmers who used polluted river water for irrigation from the river Musi in Hyderabad [32, 33]. However, [34] had made a notable observation that if the farmers are made aware of the potential risks of usage of wastewater then these hazards could be minimized in many cases. Further, urban farmers need to be trained to use new technologies like Hydroponics, Oroganoponics, zero tillage and drip irrigation which reduce the need for water and thus minimize the risk of health issues. In

this regard, extensive research and development are needed to find low-cost infrastructure and policy solutions that make better use of urban wastes for higher food production, thus reducing the vulnerability of the urban poor and helping them to strengthen the community based adaption with diversified urban food sources and income opportunities.

2.4 Biodiversity enhancement

Generally, urban landscapes have low level of biodiversity as it lacks green space. However, researchers suggested that agricultural land in and around an urban area could bring back the diverse green infrastructure and ecosystem services across the urban centre [8, 17, 35]. Thus, UPA can provide opportunities for re-vegetating the landscape at the local scale and can thereby play a positive role in conserving the native biodiversity of the urban spaces [36, 37]. UPA sites vary widely in features ranging from a small backyard garden to large orchard which may support a wide variety of plant species [38]. Studies in different urban areas of Brazil [39], Nicaragua [40], Australia [41] and Toronto [42] had documented the presence of wide diversity of vegetation types within the urban home gardens. Moreover, a multi-stratified agroforestry region can support a large amount of planned and associated biodiversity [39]. Variety and complexity in vegetative structure can create unique landscapes that are not only pleasing to the eye but provide the living conditions for many insects and vertebrates. Likewise, multiple studies had shown that the abundance of invertebrate species had been positively influenced by the diversity of vegetation within urban domestic gardens [38, 43]. Similarly, studies regarding avifaunal diversity had also shown that UPA sites with enough vegetation could support large populations of both native and exotic bird species at the local level [41]. Agricultural activities have the ability to promote biodiversity not only in UPA sites, but also in the vicinity through a ‘spill over’ effect across habitats. Such spill over may be an important mechanism for the survival of faunal species in human dominated landscapes [44].

Another important aspect of UPA is that through the conservation of faunal diversity it can potentially support ecosystem services such as pollination, seed dispersal, and pest regulation in an urban landscape [45]. Such ecosystem services within agricultural systems improve resilience of cropping patterns [46]. However, the nature and efficiency of these services largely depend on the diversity of species and vegetative structure of the UPA areas [47]. Therefore, the form and management status of UPA areas can radically influence service provision. There is, however, a notable knowledge gap on the provision of services in UPA

areas. Moreover, most of the literature on the positive relationship between urban agriculture and biodiversity lacked substantive empirical evidence [48].

3. Conclusions

This review has shown that how cities around the globe have achieved environmental sustainability through innovative solutions such as community gardens, rooftop gardens, vertical farms, and hydroponics etc. These UPA activities offer various ecosystem services and can be strategically used in mitigating the effects of climate change and urban flooding. Through nutrient recovery technology of UPA, footprint of cities can also be minimized. Therefore, the study suggests that decision-makers and urban planners should device polies to support UPA to make it a competent urban landuser. Additionally, the review adds to the current body of literature regarding the relationship between ecosystem services and UPA.

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Review Article

The Pattern of Crop Cultivation in North 24 Parganas, West Bengal – A Regional Analysis

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Abstract: Out of the total land use area in West Bengal, about 65.36 percent of the land is cultivable. In North 24 Parganas, it is about 50.23 percent. So, it is evident that agriculture is a prime part of the state economy as well as the economy of the district. This paper outlines the cropping pattern of North 24 Parganas, along with the area under major crops, where a significant variation is found throughout the year. Each crop has its strength. The crop concentration index method has been adopted to find out this feature of crop cultivation. Along with this, the agro-climatic factors behind this cropping tendency have been highlighted in this paper.

Keywords: cropping pattern, crop concentration index

Introduction

Agriculture plays an important role in Indian economy. According to census 2011, 54.6% of the population is still engaged in agriculture and allied activities. Among other states in India, agriculture is the prime economic activity in West Bengal. The reasons are that it has an almost flat alluvial plain, reaches fertile soil, and favourable agro-climatic conditions which lead to diverse agricultural patterns of the state. In the case of productivity, North 24 Parganas is the district which is having the said agricultural feature. As a result, a good amount of different crops like paddy, wheat, til, mustard, maskalai, Masur, jute, sugarcane, etc. However, a regional variation is found throughout the district. These large varieties of crops are produced in entire districts purely in rural regions. To ascertain the region where a particular crop grows well, the crop concentration index is the best method, which helps to identify the same. Hence, the Crop concentration index is being used for block-level analysis for the North 24 Parganas district.

Study area

The district is located in the South-eastern part of West Bengal, geographically between $23^0 15' 2''$ and $22^0 11' 6''$ north latitude and $89^0 5'$ and $88^0 2'$ east longitude. The district covers an area of 4094 sq. Km. and it ranks 10th among districts of West Bengal. It has 5 sub-divisional zones namely, Bongaon, Barasat, Barrackpur, Bidhannagar, Basirhat, and 22 Blocks. According to the census (2011), the district is the second-highest populated in the country and the highest in the whole state with a population of 10,009,781.

Among 520.41 (‘000 hector) gross cropped area, the net shown area is 259.22(‘000 hector) in this district. People of rural areas of this district depend on agriculture. The crop production is quite high due to agro-climatic situation is favourable for the same.

The altitude of the district is 8 m. physiographically, it falls under the ‘New alluvium’ part of the lower Gangetic deltaic plain land which is subdivided into three zones, and these are

Ichhamati-Raimangal Plain, North Bidyadhari Plain, and North Hugli flat. The northern and eastern parts of the district are drained by the Ichhamati and Raimangal River and their tributaries; the soil of this zone is recent alluvium which is a 'mature black and brownish loam' type. It is necessary to mention that, the 'North Hugli flat' is an alluvium strip along the Hugli River which is situated in the Western part of the district. The entire area is formed with silts of the Hugli River. Whereas, North Bidyadhari plain is covered with marshy land and has several sewerages. There are also good numbers of rivers, channels, and streams to drain the whole area. So, the soil of the whole region is mainly loamy and clayey-loamy type. Apart from physiography and soil, the climate provides favourable conditions for agriculture in this region. Here is a tropical humid climate with a maximum temperature of 38^0c and a minimum 10^0 c. Monsoonal rainfall occurs during the months of July August, and September. Annual average rainfall is 1208mm (2011). In all these suitable agro-climatic conditions, several crops are cultivated in this district.

Objectives

The objectives of the study are--

1. To show how different crops are concentrated in any particular part of the district.
2. To find out the nature of crop cultivation in its agro-climatic condition.
3. To identify the cropping pattern of North 24 Parganas.

Database:

The whole study is based on secondary data, which has been collected from the District Statistical Handbook (2012), Bureau of Applied Economics and Statistics, Government of West Bengal; State Statistical Handbook (2015), Bureau of Applied Economics and Statistics Department of Statistics, Government of West Bengal.

Methodology:

Bhatia's (1965) method has been adopted for delineating crop concentration of North 24 Parganas. This is as follows [13]:

$$\text{Crop Concentration Index} = \frac{\text{Area of x Crop in the Areal unit}}{\text{Area of all Crops in the areal unit}} \times \frac{\text{Area of Crop x in the whole Region}}{\text{Area of all Crops in that Region}}$$

After calculating the index value for each crop in each block they are arranged in a descending order. After that, the index scale is arranged into three classes, which are high, medium, and low. 'When the index value exceeds unity, the component areal unit contributes more than it would have if the distribution had been uniform across the region. Consequently, the areal unit has a concentration that is very significant for agriculture'[3]. For this purpose area under the principle crop which is cultivated in north 24 Parganas has been selected, from where, only food crops; major cereal, major oil seed, major fibers, and among miscellaneous vegetables, potato have been taken for calculation of crops concentration. After that, for better representation, maps have been drawn for every crop to show the regional pattern of crop cultivation. Lastly, add up every crop concentration index value for each block and arrange them into three equal classes these are high, medium, and low.

Result:

According to the formula mentioned, the crop concentration method applied for the block-wise data of North 24 Parganas has been charted out as under. Out of the chart, it appears that under the same physical condition followed by other agro-climatic conditions, a higher value of the index of one particular crop has more areal strength than other agro-products. As a result, the concentration is high as well as production contributes to a higher output in those places.

Table: 1 Calculation of Major Crop Concentration

Blocks	Paddy			Wheat	Masur	Til	Mustard	Potato	Jute
	Aus	Amon	Boro						
Bagdah	1.969	0.478	0.399	0.336	3.935	0.961	1.565	0.099	1.886
Bongaon	3.534	0.331	0.329	0.050	4.900	1.781	2.219	0.317	1.583
Gaighata	1.253	0.330	1.628	0.193	2.740	0.150	1.485	0.126	1.113
Habra-I	0.633	0.456	0.992	0.069	2.900	1.970	1.276	0.312	1.216
Habra-II	1.234	0.553	0.803	0.066	0.824	1.886	1.044	0.564	1.216
Barasat-I	0.955	0.385	0.909	0	0.903	0.930	1.939	0.062	2.238
Barasat-II	0	0.493	0.775	0.057	1.435	0.145	1.758	0.226	1.866
Amdanga	0.365	0.484	0.988	0.043	0.541	0.218	1.485	0.284	2.073
Deganga	0.616	0.428	1.268	0.886	0	0.020	1.606	0.050	1.550
Rajarhat	0.588	0.431	1.259	0.009	0.265	1.578	2.325	0.395	0.709
Barrackpur-I	0	0.390	0.509	0	10.347	2.948	2.398	0	1.363
Barrackpur-II	0	0.791	0.567	0	0.734	0	1.779	0.570	0
Baduria	1.054	0.458	1.016	0.196	0.168	0.513	1.665	0.070	1.754
Haroa	1.629	0.671	0.646	0.051	0.021	0.694	1.910	0.057	0.731
Minakhan	0.095	0.715	0.634	3.929	0	0.106	0.621	0.069	0
Swarupnagar	0.901	0.557	0.788	0.446	2.309	0.182	1.772	0.610	0.911
Hasnabad	0	0.728	0.524	0.553	0.321	0.248	2.352	0.442	0.303
Hingalganj	0	1.168	0.014	0	0.310	0	0.100	0.754	0.212
Sandeshkhali-I	0	1.071	0.791	0	0	0	0.005	0.008	0
Sandeshkhali-	0	1.157	0.235	0	0	0.012	0.661	0	0
Basirhat-I	0.198	0.574	0.780	0.667	0.487	0.093	1.327	0.576	1.5543
Basirhat-II	0.122	0.225	2.770	0.038	0.491	0.093	1.059	0.019	0.9206

Source: [4] District Statistical Hand Book 2012-13, Computed by Author

Aus:

Aus paddy is 'bhadoi' crop**.** It grows mainly in winter and partly in summer. In fact, it belongs to autumn season harvesting. Hence, the production of this paddy is not as high as that of other ones. In West Bengal production was only 471.15 (000'tonnes) during 2012-13, whereas in North 24 Parganas it is 36.08 (000'tonnes). This paddy is not cultivated in all blocks. From the calculation, it is found that, among Aus paddy-producing blocks, the concentrated in Bongaon (3.534) and medium (1.2-2.4) in Bagdah, Gaighata, Habra II. Rest is low (below 1.2).

Amon paddy:

Amon paddy is a winter crop. Among total crops, Amon is pre-dominant in West Bengal. During 2012-13 the production of this crop was 10410.533(000'tonnes). In North 24 Parganas it was 364.032(000'tonnes). Almost every block cultivate amon but the concentration is high (above 0.9) in Hingalganj, Sandeshkhali-I Sandeshkhali-II blocks and low (below 0.5) in

Bongaon, Gaighata, Bagdah, Barrackpur-I. Medium concentration (0.5-.09) is cultivated in the other parts of the district.

Boro paddy:

Boro paddy is second highest crop in West Bengal. It grows in summer. Whereas, In North 24 parganas production of Boro paddy during 2012-13 was 249.051(000'tonnes), in West Bengal, it was 4065.052(000'tonnes). Boro paddy is highly concentrated (above 1.85) in Basirhat II, medium (0.93-1.85) in Gaighata, Deganga, Rajarhat Habra-I, Baduria, but low (below 0.93) to very low in rest blocks.

Wheat:

Agro-climatic condition of West Bengal is not favourable for wheat cultivation, it is only 2 percent share of total cereals production in India. In North 24 parganas wheat produced in 2012-13 is about 19.9 (000'tonnes) and in total state, it was 859.9 (000'tonnes). In this district, the concentration of wheat is high (above 0.8) only in Minakha and Deganga, then Swarupnagar, Hasnabad, Basirhat-I, having medium concentration (1.0-0.5). In other blocks, it is very low (below 0.4).

Masur:

Masur is pre-dominant among different pulses, it is about 29 percent of total pulses produced in this state. During 2012-13 production was 61.1(000'tonnes) in this district. It was 5.05(000'tonnes). Maximum concentration (above 1.5) is found in Barrackpur I followed by Bongaon, Gaighata, Habra I, Bagdah, and Swarupnagar where the concentration is medium (1.5-0.75), in Habra I, Barasat I, and II, but very low (below 0.75) in other blocks.

Mustard:

Mustard is the most dominated oil seed produced in West Bengal. In North 24 parganas it has almost 12.8 percent share in state total production which is 474.8 (000'tonnes) in 2012-13. Due to high demand almost every block produces mustard in a certain amount. However, in this district, concentration is low (below 0.8) in Minakhan, Hingalganj, Sandeshkhali I and II. Whereas, medium concentration (0.8-1.6) is found in Bagda, Habra I, and II, Amdanga, Basirhat-I, and II block. But the rest 11 blocks have a high concentration (above 1.6) which is very significant.

Til:

Til is the second pre-dominant oil seed in West Bengal. In 2012-13 production was 179.05 (000'tonnes) and in North 24 parganas production of til is quite good. But as per the concentration index, the dry crop Til is cultivated in some blocks largely (above 1.97), these are Barrackpur I, Habra I, and medium (1.97-0.98) in Bongaon, Habra II but very less concentration (below 0.98) is found in other blocks.

Potato:

West Bengal is one of the leading potato-producing state in India, which produced 338.9(000'tonnes) in 2012-13, and North 24 parganas produced 205.19 (000'tonnes). Though overall concentration is not very high, it is maximum (above 0.50) in Hingalganj, Swarupnagar Barrackpur II, Habra II, and Basirhat I. Medium concentration (0.50-0.25) is found in Habra I, Amdanga, Bongaon, Hasnabad. Concentration is very negligible (below 0.25) in the rest of the blocks.

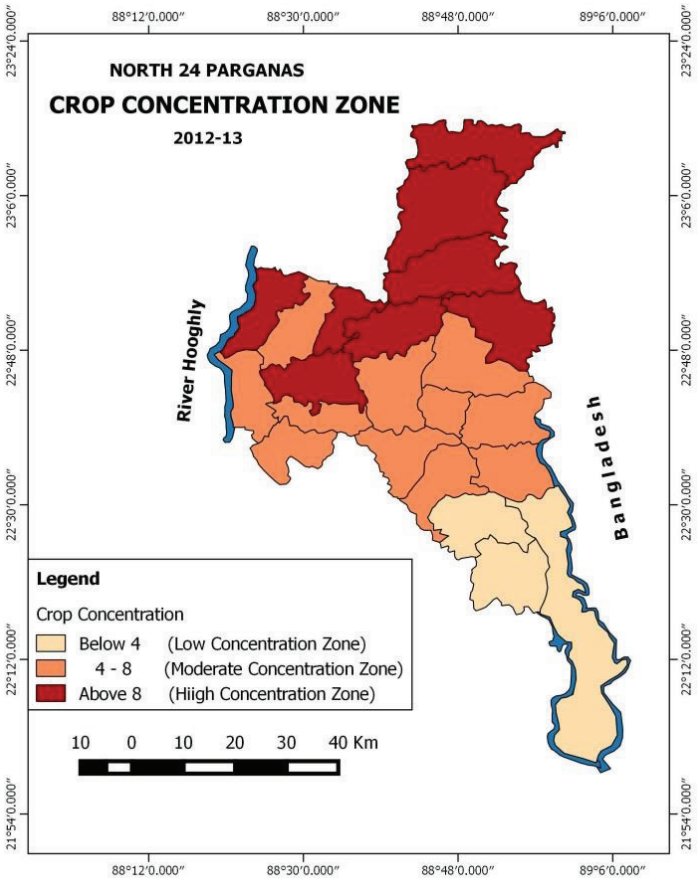
Jute:

Jute and Mesta are the main fiber crops in West Bengal. But jute is the most important cash crop. Total production in West Bengal was 8228.2 ('000 bales) and in North 24 parganas it

was 754.33('000 bales). High concentration (above 1.49), found in Barasat I and II, Amdanga, Bagdah, Bongaon, Baduria, Deganga, Basirhat I, medium concentration (1.49-0.75) found in Habra I and II, Gaighata, Swarupnagar. Whereas, the same is less (below 0.75) found in the rest of the areas.

Crop Concentration Zone:

After preparing the Crop Concentration zone map of North 24 Parganas it is depicted that, high Crop Concentration (above 8) found in northern part of the district covering Bongaon, Bagdha, Gaighata, Swarupnagar, Habra I, and II, Barrackpur I, Barasat I blocks. But the low concentration zone (below 4) showing in Hingalganj, Sandeshkhali I, and II, where the rest blocks come under the medium (4-8) class of concentration.



Source: Computed by Author

Discussion:

It tends to have a high concentration in the areas where ideal agro-climatic conditions prevail and the density declines where geographical conditions become less conductive [3]. The above result regarding the tendency of crop concentration is proving the same which had been said by Husain. From the crop concentration zone map, the suitable area cultivation, where maximum crops are cultivated may be identified, which is found in the northern part, but, gradually suitability declines towards the south.

As per climate is concerned in this district, high temperatures and dry summers, then huge rainfall in the rainy season, and slightly low temperatures in autumn and dry winter. According to the agro-ecological sub-region, it is hot sub-humid to humid, which receives

almost 1200 -1450 mm. Rainfall. This is suitable for different crop cultivation. When considering soil, it is a new alluvium type, with characteristics of sandy to clay sandy loam, the northern part is sandy loam, the central middle part is medium coarse sandy with clay loam and the southern part is very fine clay loam type. So, the soil of the district is quite fertile for good production of crops. Apart from these favourable conditions, the district is also facilitated by irrigation. Within 264.952 (^{000} hectares) net cropped area, the net irrigated area is 167.128 (^{000} hectares).

The following chart shows the ideal agro-climatic condition with their showing, growing, and harvesting time by which it can be understood why these crops are cultivated largely in this district.

Crop	Temp	Rainfall	Soil	Land type	Months											
	^{0}c	mm			J	F	M	A	M	J	J	A	S	O	N	D
Aus	21-35	1000-2000	Clay loam with P^{H}5-8	1mt depth low land												
Aman	21-35	1200-1500		Slight high												
Boro	21-35	50-75		marshy												
Wheat	15-22		Sandy-loam, well drained	Slight high												
Masur	21-30	75-100	-silt loamy, alkaline	low												
Til	warm	600	well drained Sandy-loam	Slight high												
Mustard	10-25	Less than 80	loamy	flat												
Potato	20-30	75-100	well-drained loamy with p^{H}5-7	flat												
Jute	24-35	125-200	loamy	medium flat												

Source:Purba bharoter fasal, M. Mazumdar , Computed by Author (Red -showing, Green-growing, Yellow-harvesting period)

From the above table, it is noticed that the selection of crops for cultivation comes according to their time; this indicates that the crop rotation norm is being followed here. Although this area is highly fertile, continuous cultivation of any one crop is not feasible for any productive land because the crop exhausts the soil nutrients of every cultivation. So crop rotation is necessary for this situation. 'A scientific rotation of crops not only makes agriculture a more remunerative occupation, but it also makes agro-ecosystem more resilient and sustainable' -[3]. The blocks where the kharif crop like aus paddy is cultivated in Bongaon, Bagdah, Gaighata, which have high land occupancy. After this season Masur, and mustard are cultivated for rescuing the fertility of the soil. The concentration of these crops is also found high in those blocks. Following the same manner, potato is cultivated after aman paddy, in

Sandeshkhali I and II and Hingalganj. Other than these features mixed cultivations are also carried out in different blocks. In rabi season, Boro paddy, mustard, til, and Masur are cultivated simultaneously. So these kinds of cropping features are found in North 24 Parganas.

Conclusion

The crop concentration index refers to the density of aerial occupancy of a crop in a region [15]. After the thorough study of crop concentration of North 24 Parganas, the cropping pattern is very clear in this district. Every crop has its area of concentration. For this reason, some block has a concentration of more than one crop. Proper agro-climatic conditions have supported to increase in the production of these crops. Mixed crop cultivations with crop rotation not only improve the soil condition but also maintain the sustainable agro-ecosystem of the area and it also helps the farmers to earn their recurring income.

But in comparison to other districts of West Bengal, the net cropped area is not so high in North 24 Parganas, and except mustard, no other crop production comes under the top five lists not even total crop production. The problem of agriculture in this district has arisen mainly due to rapid urbanization, especially in the western part as well as industrial development has taken part in this area and it's spreading towards east. Low yield rate (kg/hectare) except wheat, and maize, inadequate irrigation facilities, climatic hazards, etc. are also the reasons for the shortfall in agricultural output. However, further study is essential to enlighten this part. It is also pertinent to mention here that further analysis is required for its temporal change whether these problems are affecting the crop area or production.

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Research Article

An Approximate Solution For The MHD Cu-Water Nanofluid Flow Over Exponentially Stretching Permeable Sheet With Velocity And Thermal Slip Using Homotopy Perturbation Method

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Abstract: This investigation analytically described the effect of magnetic field, radiation and heat generation on the boundary layer flow of Cu-water nanofluid over a stretching porous surface. The governing equations are transformed to ordinary differential equations use of suitable similarity transformations. The resulting highly non-linear coupled differential equation has been solved analytically by homotopy perturbation method (HPM). The influences of various pertinent parameters are analyzed for velocity, temperature, skin-friction and heat transfer rate in detail through graphs and Table. It was noticed that velocity profiles decreased and the temperature profiles increased for the increasing value of nanoparticle volume fraction ϕ_0 (Cu). Also the findings suggest that increasing value of Magnetic field parameter M decrease both the skin friction coefficient and the heat transfer rate.

Keyword: Nanofluid, Stretching surface, Heat transfer, Velocity slip condition, HPM

Introduction:

The rheology of nanofluid flow in the porous media has become major academic research topics over the years because of its important in natural sciences, engineering, and industries. Nanofluids possess a significantly higher thermal conductivity than regular fluids. Therefore, nanofluids are widely used for a wide range of applications, such as nuclear cooling, cooling of vehicles and machinery, electronic device cooling, biomedicine, etc. Choi and Eastman [1] was the first to introduce the word nanofluid that represent the fluid in which nanoscale particles (diameter less than 50 nm) are suspended in the base fluid. Consequently many researchers have investigated the behaviours and properties of nanofluids for different aspects, numerically and experimentally. Tiwari and Das [2] have proposed mathematical model of nanofluids that study the nanofluids' behaviour considering the solid volume fractions of nanoparticles' effects. Zaimi et al. [3] studied the boundary layer flow and heat transfer past a permeable shrinking sheet in a nanofluid with radiation effect. Magyari and Keller [4] studied boundary layer flow and heat transfer due to an exponentially stretching continuous surface. Makinde and Aziz [5] investigated the effects of convecting heating on boundary layer nanofluid flow past a stretching sheet.

No-slip condition has been used in most of the above investigations. But the no-slip condition at the solid fluid interface is no longer applicable when fluid flows in microelctromechanical

system (MEMS). Merkin et al. [6] analyzed mixed convection boundary layer flow with temperature slip boundary condition in a porous medium. Then many researchers [5-14] have analyzed the fluid flow for different aspects in a slip flow regime.

Most of the above problem are nonlinear and solved numerically. To find the approximate analytical solution for a nonlinear ordinary and partial differential equations or coupled nonlinear system of partial differential equations recently developed a method called Homotopy perturbation method (HPM). The pioneer work in HPM was studied by J. H. He [15-17]. This approach, when compared to other analytical processes, makes computing analytical results simpler and faster, and various academics [18-19] have utilized it in their respective fields of study. Thus, HPM-based methods for resolving nonlinear problems, such as nonlinear heat transfer, fluid mechanics, and many others, have been employed.

In this study, my objective is to investigate the boundary layer of Cu-water nanofluid flow and heat transfer due to an exponentially stretching permeable sheet in the presence of magnetic field and slips boundary conditions. With the help of suitable similarity transformations, the governing PDEs were reduced to a set of nonlinear ODEs. Then using HPM these equations were solved analytically. The effects of the various physical parameters on velocity and temperature have been reported. The skin friction coefficient and the rate of heat transfer are also presented in tabular form for several values of the physical parameters.

Formulation of the problem:

A steady, incompressible boundary layer of Cu-water nanofluid slip flow through a Darcy-Forchheimer porous medium past an exponentially permeable stretching sheet is considered. The nanofluid is assumed to flow with velocity $\bar{u}$ in the x direction while velocity $\bar{v}$ in the y direction, normal to x -coordinate. The deformable surface has a velocity $\bar{u}_w(x) = \bar{u}_0 e^{x/L}$ with $\bar{v}_w(x) = \bar{v}_0 e^{x/2L}$ is the constant mass flux velocity. Further, an applied magnetic field $\bar{B} = \bar{B}_0 e^{x/2L}$ with constant strength is directed normal to the flow zone plane $y = 0$. The number of Renolds is small because the induced magnetic field and impressed electric field are ignored. An assumption of variable wall temperature is made such that $\bar{T}_w = \bar{T}_\infty + \bar{T}_0 e^{x/2L}$ with constant $\bar{T}_0 > 0, (\bar{T}_w > \bar{T}_\infty)$ represents a heated sheet for assisting flow whereas $\bar{T}_0 < 0, (\bar{T}_w < \bar{T}_\infty)$ signifies a cooled sheet for opposing flow. The nanofluid thermal conductivity is to vary as a linear function of temperature, $\bar{T}$. Thermal properties of nanofluid change significantly with a rise in temperature, type of nanoparticles, pressure etc. Finally, the nanofluid is considered optically thick, radiative heat transfer is taken into account, and the Rosseland approximation is utilized for the radiation effects. The nanoparticle are assumed to be in thermal equilibrium with the base fluid. Under all the mentioned assumptions, the coupled boundary layer continuity, momentum and energy equations, including boundary conditions are formulated as follows:

$$\frac{\partial \bar{u}}{\partial x}+\frac{\partial \bar{v}}{\partial y}=0, \tag{1}$$

$$\bar{u}\frac{\partial \bar{u}}{\partial x}+\bar{v}\frac{\partial \bar{v}}{\partial y}=\frac{\mu_{nf}}{\rho_{nf}}\frac{\partial^2 \bar{u}}{\partial y^2}-\frac{\mu_{nf}}{\rho_{nf}}\frac{\bar{u}}{k^*}-\frac{F^*}{\sqrt{\mathrm{K}^*}}\bar{u}^2-\frac{\sigma_{nf}\bar{B}^2}{\rho_{nf}}\bar{u}, \tag{2}$$

$$\bar{u}\frac{\partial \bar{T}}{\partial x}+\bar{v}\frac{\partial \bar{T}}{\partial y}=\frac{\kappa_{nf}}{(\rho C_p)_{nf}}\frac{\partial^2 \bar{T}}{\partial y^2}-\frac{1}{(\rho C_p)_{nf}}\frac{\partial \bar{q}_r}{\partial y}+\frac{\bar{Q}}{(\rho C_p)_{nf}}(\bar{T}-\bar{T}_\infty), \tag{3}$$

subject to the appropriate boundary conditions:

$$\bar{u}=\bar{u}_w+\bar{u}_{slip}, \bar{v}=\bar{v}_w, \bar{T}=\bar{T}_w\,(x)+C_1\frac{\partial \bar{T}}{\partial y} \qquad \text{at } y=0, \tag{4}$$

$$\bar{u}\to 0,\ \ \bar{T}\to \bar{T}_\infty \qquad \text{as } y\to\infty, \tag{5}$$

in where $\bar{Q}=\bar{Q}_0 e^{x/L}$ is the heat generation rate constant and $C_1=c\ e^{x/2L}$ represent the temperature slip factor depend on x, respectively. the correlation with physical properties of nanofluid density ρ_{nf}, heat capacitance $(\rho C_p)_{nf}$, dynamic viscosity μ_{nf}, thermal conductivity κ_{nf}, electrical conductivity σ_{nf}, employed in Eqs. (1)-(4) are characterized in Table-1. The $\bar{u}_{slip}$ takes the form:

$$\bar{u}_{slip}=\frac{2}{3}\left(\frac{3-\alpha l^3}{\alpha}-\frac{3}{2}\frac{1-l^2}{\mathrm{K}_n}\right)\gamma_0\frac{\partial \bar{u}}{\partial y}-\frac{1}{4}\left(l^4+\frac{2}{\mathrm{K}_n^2}(1-l^2)\right)\gamma_0^2\frac{\partial^2 \bar{u}}{\partial y^2}=A_1\frac{\partial \bar{u}}{\partial y}+B_1\frac{\partial^2 \bar{u}}{\partial y^2}, \tag{6}$$

Where $l=\min\left(\frac{1}{\mathrm{K}_n},1\right), \alpha(0\le\alpha\le 1)$ is the momentum accomodation co-efficient and $\gamma_0(>0)$ is the mean free path. Hence for any Kundsen number (K_n), $A_1>0$ and $B_1<0$. Applying Rosseland approximation of radiation to gray/optical thick media and the net radiation heat flux $\bar{q}_r$ can be approximated as an isotropic diffusion process by the expression

$$\bar{q}_r=-\frac{4\sigma^*}{3K^*}\frac{\partial \bar{T}^4}{\partial y}, \tag{7}$$

Here $\bar{T}^4$can be expanded as Taylors series about $\bar{T}_\infty$ and neglecting the higher order terms, we have

$$\bar{T}^4\approx 4\bar{T}_\infty^3\bar{T}-3\bar{T}_\infty^4, \tag{8}$$

To non-dimensionalise the aforementioned the Eqs. (1)-(5), the following similarity variables are introduced:

$$\psi=e^{x/2L}\sqrt{2\nu_f L\bar{u}_0}g(\eta), \bar{u}=\frac{\partial \psi}{\partial y}, \bar{v}=\frac{\partial \psi}{\partial x}, \theta(\eta)=\frac{\bar{T}-\bar{T}_\infty}{\bar{T}_w-\bar{T}_\infty},\ \eta=ye^{x/2L}\sqrt{\frac{\bar{u}_0}{2\nu_f L}}, \tag{9}$$

With transform Eqs. (2)-(3) into the non-dimensional subsequent equations, before gratifying Eq.(1).

From equation (2),

$$\left(\frac{\mu_{nf}/\mu_f}{\rho_{nf}/\rho_f}\right)g''' + gg'' - 2g'^2 - \left(\frac{\mu_{nf}/\mu_f}{\rho_{nf}/\rho_f}\right)Pg' - F_r g'^2 - \left(\frac{\sigma_{nf}/\sigma_f}{\rho_{nf}/\rho_f}\right)Mg' = 0,$$

or, $g''' + A_4 gg'' - E_1 g'^2 - F_1 g' = 0,$ (10)

From Eq. (3)

$$\frac{1}{P_r}\left(\frac{\kappa_{nf}}{\kappa_f} + R_d\right)\theta'' + \frac{(\rho C_p)_{nf}}{(\rho C_p)_f}(g\theta' - g'\theta) + R\theta = 0,$$

or, $\theta'' + L_1(g\theta' - g'\theta) + L_2\theta = 0,$ (11)

Where A_4, E_1, F_1, L_1 and L_2 are constants.

With subjected boundary conditions:

$g(0) = S,\ g'(0) = \xi + Ag''(0) + Bg'''(0), \theta = 1 + C\theta'$ at $\eta = 0$ (12)

$g' \to 0,\ \theta \to 0$ as $\eta \to \infty$ (13)

Here we consider, $\xi\ (= 1)$ is stretching sheet parameter. Also, the emerging physical parameters Magnetic field parameter M, porosity parameter P, Forchheimer number F_r, Prandtl number P_r, thermal radiation parameterR_d, Heat generation R, first order velocity slip parameter A, second order velocity slip parameter B, thermal slip parameter C, wall mass flux transfer parameter S, are defined by

$$M = \frac{\sigma_f B_0^2 L}{\bar{u}_0 \rho_f}, P = \frac{\nu_f}{\bar{u}_0 k^*}, F_r = \frac{xF^*}{\sqrt{k^*}}, P_r = \frac{(\mu C_p)_f}{\kappa_f}, R_d = \frac{16\sigma^* \bar{T}_\infty^3}{3\kappa_f K^*}, \beta = \frac{2\bar{Q}_0 L}{\bar{u}_0 (\rho C_p)_f},$$

$$A = A_1\sqrt{\frac{\bar{u}_0}{2\nu_f L}}\, e^{x/2L}, B = B_1\sqrt{\frac{\bar{u}_0}{2\nu_f L}}\, e^{x/2L}, C = C_1\sqrt{\frac{\bar{u}_0}{2\nu_f L}}, S = -\bar{v}_0\sqrt{\frac{\nu_f \bar{u}_0}{2L}}$$

To have similarity solutions, the quantities A and B must be constants and it is possible if the mean free path of the nanoparticles γ_0 is proportional to $e^{x/2L}$. We therefore assume $\gamma_0 = de^{-x/2L}$. Where d is the proportionality constant.

Solution with Homotopy Perturbation Method (HPM):

According to the HPM, the homotopy form of Eqs. (10) and (11) are constructed as follows:

$$(1-q)(g''' - F_1 g') + q[g''' + A_4 gg'' - E_1 g'^2 - F_1 g'] = 0 \quad (14)$$

$$(1-q)(\theta'' + L_2\theta) + q[\theta'' + L_1(g\theta' - g'\theta) + L_2\theta] = 0 \quad (15)$$

We consider g and θ as following:

$$g = g_0 + qg_1 + q^2 g_2 + \cdots \quad (16)$$

$$\theta = \theta_0 + q\theta_1 + q^2\theta_2 + \cdots \quad (17)$$

Substituting Eq.(16) into Eq.(14) and equating the like terms and neglecting higher order of q, we find

$$g_0''' - F_1 g_0' = 0 \quad (18)$$

$$g_1''' - F_1 g_1' + A_4 g_0 g_0'' - E_1 g_0'^2 = 0 \quad (19)$$

The corresponding boundary conditions are

$$g_0(0) = S, g_0'(0) = \xi + Ag_0'' + Bg_0'''(0), g_0'(\infty) = 0 \quad (20)$$

$$g_1(0) = S, g_1'(0) = \xi + Ag_1'' + Bg_1'''(0), g_1'(\infty) = 0 \quad (21)$$

Substituting Eq.(17) into Eq.(15) and neglecting higher order of q, we find

$$\theta_0'' + L_2\theta_0 = 0 \quad (22)$$

$$\theta_1'' + L_2\theta_1 + L_1 g_0\theta_0' - L_1 g_0'\theta_0 = 0 \quad (23)$$

The corresponding boundary conditions are

$$\theta_0(0) = 1 + C\theta_0'(0), \theta_0(\infty) = 0 \quad (24)$$

$$\theta_1(0) = C\theta_1'(0), \theta_1(\infty) = 0 \quad (25)$$

Solving Eqs. (18-19) and (22-23) with boundary conditions (20-21) and (24-25) respectively,

We have

$$g_0 = d_1 + d_2 e^{-\sqrt{F_1}\eta} + d_3 e^{\sqrt{F_1}\eta} \quad (26)$$

$$g_1 = d_4 + d_5 e^{-\sqrt{F_1}\eta} + d_6 e^{\sqrt{F_1}\eta} - h_{10}\eta e^{-\sqrt{F_1}\eta} - h_{11}\eta e^{\sqrt{F_1}\eta} + h_{12} e^{-2\sqrt{F_1}\eta} - h_{13} e^{2\sqrt{F_1}\eta} + h_{14}\eta \quad (27)$$

$$g(\eta) = g_0(\eta) + qg_1(\eta) \quad (28)$$

$$\theta_0 = d_7 \cos\left(\sqrt{L_2}\eta\right) + d_8 \sin\left(\sqrt{L_2}\eta\right) \quad (29)$$

$$\theta_1 = d_9 \cos\left(\sqrt{L_2}\eta\right) + d_{10} \sin\left(\sqrt{L_2}\eta\right)\ d_{25}\,\eta\cos\left(\sqrt{L_2}\eta\right) + d_{26}\,\eta\sin\left(\sqrt{L_2}\eta\right) + d_{27} e^{-\sqrt{F_1}\eta}\cos\left(\sqrt{L_2}\eta\right) + d_{28}\, e^{-\sqrt{F_1}\eta}\sin\left(\sqrt{L_2}\eta\right) + d_{29} e^{\sqrt{F_1}\eta}\cos\left(\sqrt{L_2}\eta\right) + d_{30}\, e^{\sqrt{F_1}\eta}\sin\left(\sqrt{L_2}\eta\right) \quad (30)$$

$$\theta(\eta) = \theta_0(\eta) + q\theta_1(\eta) \quad (31)$$

Where d's and h's are constants.

The constant co-efficients, can be calculated using boundary condition $\eta = \infty$ were replaced by those at $\eta = 5$ in accordance with standard practice in the boundary layer analysis. If $q \to 1$, we find the approximate solution of Eqs.(14) and (15). The constant coefficients are defined in the Appendix.

Table1.

Thermophysical properties of nanoparticle and base fluid as follows (Gopinath [24])

Physical Properties	Water	Cu
C_p (J/KgK)	4179	385
ρ (Kg/m^3	997.1	8933
κ (w/mK)	0.613	400
σ (Ω/m)	0.05	59.6×10^4

Introducing nanofluid constants is as follows,

ρ_{nf}= (1-ϕ_0)ρ_f + $\phi_0\rho_s$,

$\left(\rho C_p\right)_{nf}$ = (1-ϕ_0) $\left(\rho C_p\right)_f$+ $\phi_0\left(\rho C_p\right)_s$,

$\kappa_{nf} = \kappa_f \left[\frac{\kappa_s+2\kappa_f-2\phi_0(\kappa_f-\kappa_s)}{\kappa_s+2\kappa_f+2\phi_0(\kappa_f-\kappa_s)}\right]$,

$\alpha_{nf} = \frac{\kappa_{nf}}{(\rho C_p)_{nf}}$, $\mu_{nf} = \frac{\mu_f}{(1-\phi_0)^{2.5}}$,

Physical Quantities:

From a science and engineering perspective, the physical quantities of curiosity like shear stress coefficient, drag force and heat flux have plentiful applications. The mathematical expressions for the material significant amounts in flow and heat transfer of nanofluid flow skin-friction coefficient C_f and Nusselt Number Nu_x, which are defined as:

$$C_f = \frac{\mu_{nf}}{\rho_f \bar{u}_w^2}\left(\frac{\partial \bar{u}}{\partial y}\right)_{y=0}, Nu_x = \frac{\left[\kappa_{nf}\left(-\frac{\partial \bar{T}}{\partial y}\right)+\frac{4\sigma^*}{3K^*}\left(-\frac{\partial \bar{T}^4}{\partial y}\right)\right]_{y=0}}{\kappa_f(\bar{T}_f-\bar{T}_\infty)} \quad (32)$$

Finally the skin-friction coefficient and local Nusselt number can be expressed as

$$(2Re)^{1/2}e^{x/L}C_f = \frac{\mu_{nf}}{\mu_f}g''(0), \sqrt{2L/x}\,Re_x^{1/2}Nu_x = -\left(\frac{\kappa_{nf}}{\kappa_f} + R_d\right)\theta'(0) \quad (33)$$

Where $Re = \bar{u}_w(x)\,L/\nu_f$ is the Reynolds number and $Re_x = \bar{u}_w(x)\,x/\nu_f$ is the local Renolds number.

Table 2
Comparison of $-g''(0)$ and $-\theta'(0)$ with different values of parameters.

S	M	P	ϕ_0	$-g''(0)$	$-\theta'(0)$
2.0	0.1	1.0	0.1	2.401667595	0.903821111
2.5	0.1	1.0	0.1	2.609520197	1.007648945
3.0	0.1	1.0	0.1	2.817372322	1.111477017
2.0	0.1	1.0	0.1	2.401667595	0.903821111
2.0	0.2	1.0	0.1	2.332629681	0.888163149
2.0	0.3	1.0	0.1	2.271768570	0.873962581
2.0	0.1	1.0	0.1	2.401667595	0.903821111
2.0	0.1	2.0	0.1	1.962006450	0.795637488
2.0	0.1	3.0	0.1	1.758499861	0.738444805
2.0	0.1	1.0	0.01	2.038030863	1.123711228
2.0	0.1	1.0	0.05	2.234545469	1.016836643
2.0	0.1	1.0	0.1	2.401667595	0.903821111

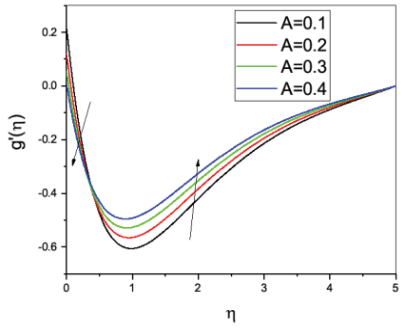

Fig.1. (a)

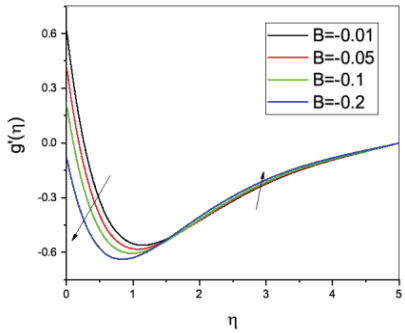

Fig.1.(b)

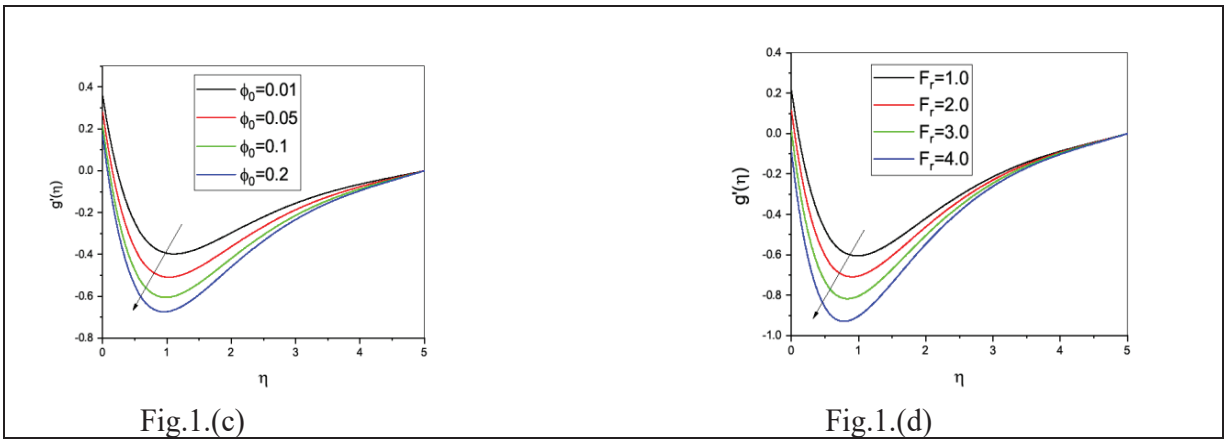

Fig.1.(c) Fig.1.(d)

Fig.1. Velocity profiles against η for different values of A, B, ϕ_0 and F_r.

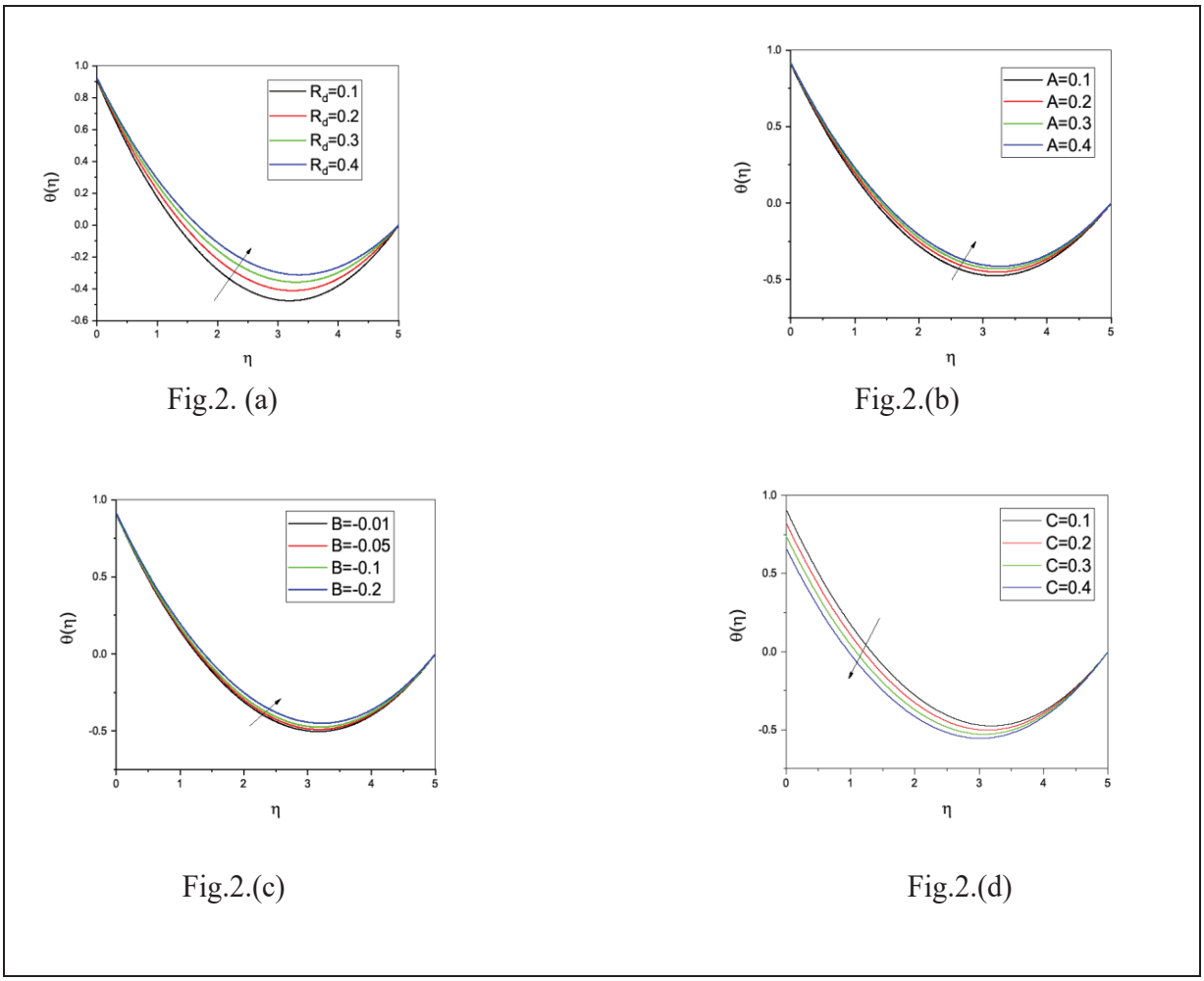

Fig.2. (a) Fig.2.(b)

Fig.2.(c) Fig.2.(d)

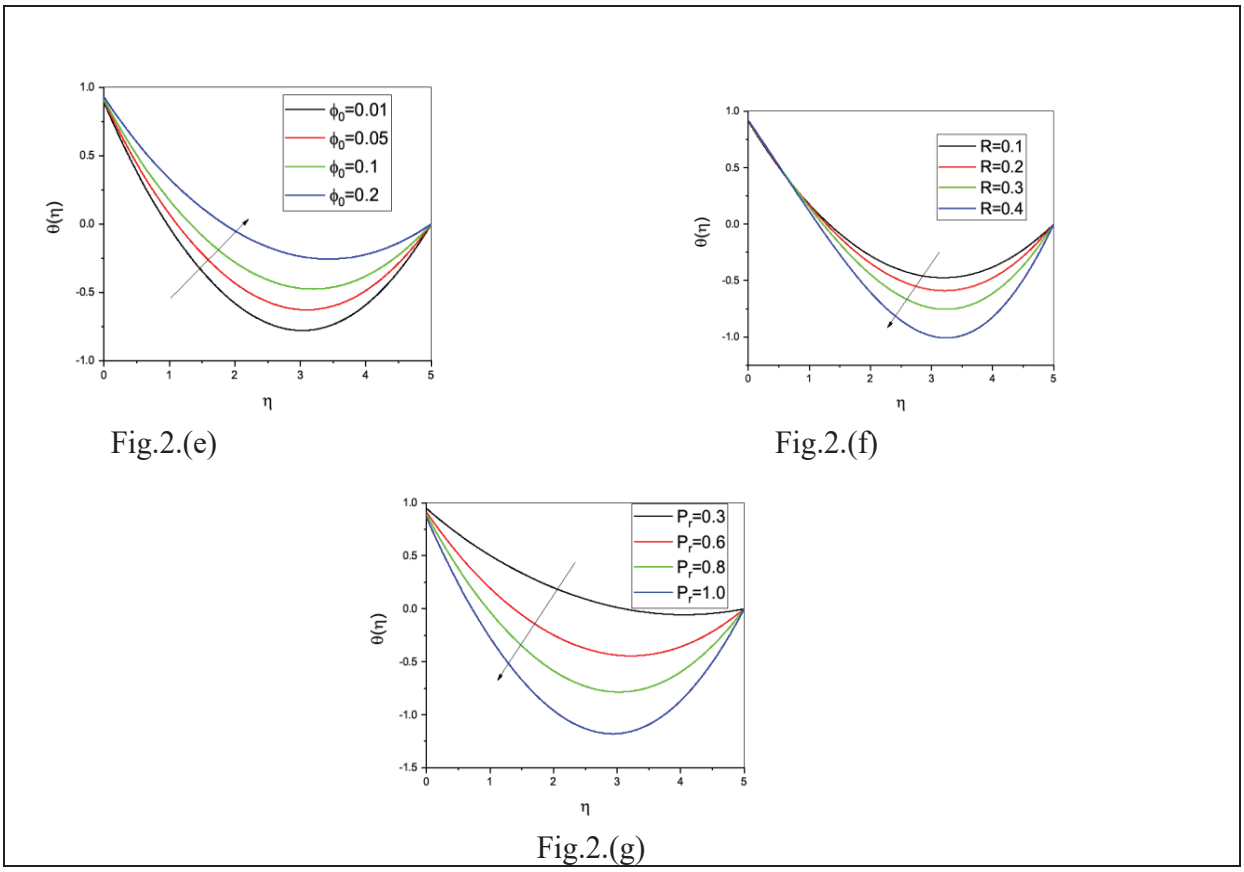

Fig.2.(e) Fig.2.(f)

Fig.2.(g)

Fig.2. Temperature profiles against η for different values of R_d, A, B, C, ϕ_0, R and P_r.

Results and discussions:

In this study, the numerical results are obtained for different values parameters $M, P_r, \phi_0, A, B, C, R_d, R, F_r$ with fixed values HPM parameter ($q = 1.0$) and stretching parameter ($\xi = 1.0$) implanted in the flow system. A systematic study of selected control parameters governing the flow regime has been conducted and the results are depicted in Figs. 1-2 and Table2. In the present computations the following default parameter values have been prescribed $\phi_0 = 0.1, A = 0.1, B = -0.1, C = 0.1, P_r = 0.62, R_d = 0.1, M = 0.1, P = 1.0, S = 2.0, F_r = 1.0, \xi = 1.0, q = 1.0$. Table2. Depicts the skin friction coefficient and rate of heat transfer for different values of S, M, P, ϕ_0. It is seen that the increasing values of S and ϕ_0 the skin friction coefficient increases whereas increasing values of M and P decreases the skin friction coefficient. It is also observed that rate of heat transfer increases with an increase in S and heat transfer rate decreases with the increase of M, P and ϕ_0.

Fig.1. depicts the effect of parameters A (Fig.1.(a)), B (Fig.1.(b)), ϕ_0 (Fig.1.(c)) and F_r (Fig.1.(d)) on velocity profile against η. From this figure it is found that velocity decreases near the wall with the increase of A and B whereas the reverse effect is seen far away from the wall. From this figure it is also seen that velocity decreases with the increase of ϕ_0 and F_r throughout the boundary layer. Fig.2. presents the effect of parameters R_d (Fig.2.(a)), A(Fig.2.(b)), B(Fig.2.(c)), C (Fig.2.(d)),ϕ_0 (Fig.2.(e)), R (Fig.2.(f)) and P_r (Fig.2.(g)) on temperature profile against η. It is found that temperature increased with the increasing $R_d, A, B,$ and $\phi_0$throughout the boundary layer and reverse effect is seen for increasing values of C, R and P_r.

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Review Article

Russia-Ukraine War: the shockwave and implications for the Nation-state

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Abstract: The author has followed the nitty-gritty's of the war since its outbreak on February 24, 2022. It is not the outcome of sudden interest or merely reading from certain websites but data from various web sources were collected for last two years based on which this piece was articulated. Here the aim of the author is to highlight the ubiquitous concern that gets exacerbated each day as the war continues. In the absence of any signal of precipitous conclusion of the war, this concern upholds the most sagacious realization that enough is enough. Give us respite from the impending catastrophe of ecocide that has started taking its toll. But that is one aspect of the story; the other one is more subjective, nuanced but no less major and perhaps more worth-listening to because we find an attitude on the part of the migrants who brave the risk of coming back to Ukraine, their original domicile amidst ongoing war which exhibits a reaction of determination to negate and ignore the war thrown upon them by the state system. Its implications are complex but there is no denying the fact that sovereignty of states does not authorize it to play with emotions, interests of the people and their bond with nature.

Key words: war, Russia, Ukraine, Europe, environment, toxic, mental- health.

Introduction

First we need to put the Russia-Ukraine crisis in proper historical perspective without tilting in favour of the Western narrative that puts blame entirely on Russia or its hidden imperial design for a greater Slavic state linked to its innate quest for greater status in international politics. To some extent it appears valid but not the whole story because the crux of the real issue lies not in military counter-offensive to Russia but to search for a new paradigm which can help us to think anew about our current crisis-ridden condition and the need and direction toward a desirable change, not mere course correction. It is this realization that operates at the back of our minds when we raise 2 prime aspects of the fall-out of the currently ongoing war, viz., i) increasing energy crisis plaguing Europe and ii) impact of this protracted conflict (now dragging for more than two years) on environment which is far more lethal and going to be damaging in the long run because if the larger ecosystem is poisoned, then it is bound to affect the common pool of resources including atmosphere, river water, forests, soil layers, farming, livestock etc. Yet it is bewildering and agonising to find that two mighty capitalist

powers keep on brandishing swords against one another while the prime task before us should have been a collective enterprise for rebuilding our relation with nature. Thus the irony of the situation lies in the fact that on one hand we want happiness through our integral relationship with nature while on the other hand, we believe in fierce nationalism, statism and leadership ego which create a false narrative of growth at the cost of healthy natural conditions. As such, when a war or geo-political tension breaks out between two or more sovereign units, political leaders often become so rigid and vainglorious about their narrow perspective that allows little attention to either such conflict's wider spill-over impact on society, economy and environment, thereby shutting all doors for any alternative sustainable solution, as if the *cul de sac* of primitive muscle-flexing since the days of the Sumer-Elam conflict is the ideal rule of the game. This aside, a kind of obstinate Realist view takes precedence in completely submerging and subordinating our umbilical solidarity with nature as if we tend to forget that state cannot be an end in itself. That is precisely what endangers nature which we ignore at the altar of crude strategic reasons. **As such, when calculations of sovereignty and force projection to achieve relative advantage over adversary writs large, the prognosis indicate that it is environment that stands to be the real LOSER in the long run because direct effect of conflict asunder, a major war can always slow down and even dismantle the development of global consensus on institution building, international regime, its framework of actions and agenda which takes years to crystallize**. So, this is all about the first story which will be elaborated through three part discussion to be followed up by the fourth part concerning the second story, thus inevitably wrapping up the findings in the concluding section.

Discussion: Part-I

As the war continues for various reasons of western backing of Ukraine with aid and supply of ammunition and as it enters a new phase, we are now hearing about new escalations from conventional military offensive to nuclear warfare and the gloomy prospect of inching towards the THIRD WORLD WAR.

So let us posit a few points that would make the case quite convincing as to the degree of damage to environment, economy and its implications and ramifications:

1. According to authoritative sources like the UNEP over 12,000 square kilometers of Ukraine's natural reserves have become a war zone. Populations living on forest resources and migrant species have suffered significant losses. It also apprises that

birds have been forced to abandon nests and alter migration routes. Decades-long conservation efforts have been undermined [1].

2. Similarly explosions from military activities have not only caused physical destruction but also inflicted toxic damage on the environment [2]. The Ukrainian government, journalists, and international observers have described this damage as "**ecocide**". It is a common knowledge that explosives like TNT, DNT, and RDX are used in warfare. After each explosion, particles of toxic materials such as lead, mercury etc. are released into the air, water, and soil, causing huge contamination and posing multiple risks from affecting agricultural productivity, creating water scarcity, destroying building, releasing carcinogenic dust, which remains hazardous for decades. Inhalation of this dust poses long-term health risks.

3. Another important aspect to keep in mind is that when the war had began the West, European Union and the US responded by deploying and imposing unprecedented sanctions against Russia [3] purporting to force it to retreat. But two points are very pertinent in this connection:

One is that such crippling sanctions have already caused massive disruption in world's energy, financial and trading system with devastating consequences for states, particularly weaker developing countries that are not parties at all to the conflict. So here the principle of international justice has been completely violated.

Secondly, all hopes behind the sanctions proved futile as Putin's Russia did not budge and bend down before it. On the contrary, some observers noted that the Russian rubble was fast approaching its pre-invasion value due to steps taken by Russia to shore up its economy [4]. Even experts suggested that the Western sanctions on Moscow were not comprehensive but hasty and there were major loopholes in sanction measures to target Russia that enabled it to evade the sanctions without much difficulty.

The US and Europe had thought that taking off Russia from the SWIFT payment system would hamper Russia's ability to trade in the international market. But, that turned out to be

[1] See https://www.unep.org/resources/report/environmental-impact-conflict-ukraine-preliminary-review.
[2] See https://occup-med.biomedcentral.com/articles/10.1186/s12995-023-00398-y.
[3] See the Press Release by the US Treasury on Feb 24, 2022 regarding its significant and unprecedented action to respond to Russia's further invasion of Ukraine by imposing severe economic costs that will have both immediate and long-term effects on the Russian economy and financial system.
[4] See brief commentary by V. Thardak entitled " Why did the Western Sanctions on Russia fail??" via https://tfiglobalnews.com/2022/03/30/why-did-the-western-sanctions-on-russia-fail/

just wishful thinking. Major economies like China and India were prompt to switch over to alternative mechanisms like setting up of a Yuan and Rupee denominated trading mechanism that benefitted these countries. The West came to realize the hard reality that punishing to inflict large-scale damage to Russian economy won't be a cakewalk to accomplish.

The US approach was also mistaken in the sense it thought it could move ahead without taking allies in confidence. As such major US allies like the Saudi Arabia, India did not follow the US line; rather they differed from the step of sanctioning Russia. Instead, they were taking a neutral stance, thus giving Russia more manoeuvring room to circumvent the American sanctions. For example, India agreed to buy Russian oil in Rupee denominated currency [5].

Part-II

Today when we are worried about Putin's threat escalation to go nuclear, we cannot gloss over that Ukraine might have a nefarious motive too. According to Russian source, this time, Ukraine was desperately planning to go a step further. It planned to **use the 'dirty bomb'[6] to pose potential damage to nature and living species**. A dirty bomb is a form of "**radiological dispersal device (RDD)**" intended to pollute a vast region with its powerful radioactivity without requiring detonation of a nuclear device[7], thus rendering the land unfit for living. This type of weapon has long been considered as a possible means of terrorist violence since its main purpose is to spread radioactive particles and asphyxiating smoke into the air that unleashes mass hysteria to erode the morale of resistance. Earlier there was alarming apprehension about extensive human health risks when such story was circulated that al-Qaeda could plot to detonate a dirty bomb even in a college football game. It shows how endemic the problem has become that makes the role of the European Union or the UN as a centre of policy initiation on such issues a daunting task.

[5] According to experts like J. Panda, this hike in India-Russia energy trade, however, was not significant but to be seen from transactional standpoint which had nothing to do with long-term strategic partnership or multipolar narrative (See https://www.usip.org/publications/2024/02/limitations-india-and-russias-transactional-relationship)

[6] On October 23, Russian Defense Minister Sergei Shoigu claimed that Ukraine was preparing to use a "dirty bomb"—a weapon that uses conventional explosives laced with radioactive material. In a series of phone calls to his counterparts in France, Turkey, the United Kingdom, and the United States, Shoigu said that he was "concerned about possible provocations by Kyiv involving the use of a dirty bomb."(See https://thebulletin.org/2022/10/russia-says-ukraine-is-preparing-a-dirty-bomb-is-it-true-and-what-does-it-mean/)

[7] See R. Yadav's opinion piece entitled "Ukraine had a terrific plan to use 'dirty bombs' against Donbas' residents but it got exposed" on https://tfiglobalnews.com/2022/10/28/ukraine-had-a-terrific-plan-to-use-dirty-bombs-against-donbas-residents-but-it-got-exposed/

However, if we consider deeply we would have certainly cancelled out such flimsy propaganda of Ukraine's use the 'dirty bomb' simply because Ukraine is still grappling to cope with the consequences of 1986 Chernobyl nuclear plant disaster. So there is no question of repeating the same mistake of spreading radiation unless the regime goes insane or does so at the cost of suicide.

In the present context a host of challenges are bubbling up that could test resilience of Europeans, their market system and democratic stability. It may be noted that already fumes of anti-war demonstrations and protests to government approach of managing adverse economic situation are plaguing countries like France. Besides, mass migration from Ukraine[8]—according to UNHCR, in Europe the number of which has increased slightly in 2023 (+5%) compared to 2022 (5.7 million), though its long term impact would be gradually revealing in future. However, it is important to take cognizance of one good sign that unlike previous refugee crises, all the neighbouring countries of Ukraine which are members of the EU have accepted Ukrainian refugees[9]. But as the war continues and casualties multiply, future seems to be bleak with possibility of ethnic tensions, controversy on rehabilitation of refugees coupled with inflationary uptick that casts a gloomy spectre on economic front of Europe at large.

Part-III

As the economic situation in Western Europe is in shambles, we see discontents are rising about failure of Europe to keep its commitment elsewhere insofar as environmental protection is concerned. As thousands burst into protests in Kenya's capital recently against the West for not doing enough to address the climate change crisis. Kenya is facing acute drought which demonstrators in the country relate to global warming. Similarly the UN News flashed a report in June 2022 that women and children face deadly consequences in the Somali region of Ethiopia due to worst drought conditions. These are some eye-openers to the vulnerable health conditions of aid dependent population. In this context we have to appreciate the perception of the protestors who think that they have been trapped between the power-play of rich European nations. The protest march was part of Pan African Climate

[8] As per the data provided by UNHCR's Ukraine Population Movement Factsheet1.pdf, the peak of the displacement occurred during the first four months of the full-scale invasion. Gradually, border crossings from and to the western borders of Ukraine have tended to stabilize over time, with more than 1 million monthly movements from and to Ukraine (each) during 2023, according to data shared by national authorities in host countries neighbouring Ukraine.

[9] According to data published by EUROSTAT, between January and December 2023, over 1,032,000 migrants from Ukraine were granted Temporary Protection (TP) in EU+ countries.

Justice Alliance, a youth-movement in Kenya which holds demonstrations and rallies calling on rich nations to pay compensation for global warming. There is no denying the fact that 96 percent of the emissions are being emitted by the Global North. Africa or any individual state although victim of global climate catastrophe is not in a position to rectify the crisis. Hence they are demanding for their rightful dues from the Global North in terms of payment for the loss and damage. Thus these protests are creating new lines of pan-African solidarity and struggle for justice while reflecting new awareness of rights based on the fundamental principle of symbiosis between nature and human life.

Yet, the West has always dominated discourse on the environment with its racist, imperial and colonial knowledge system. The EU and the US, in particular, have always used their powers to dominate the world. The West has always occupied the role of a leader in the global climate conferences which has given it an advantage over Africa [10]. It has abused this position to go against those nations which dare to question the motive of the superpowers and start seeing their ulterior motive intended to create an atmosphere of panic among African and Asian states. The real purpose of the West is, therefore, not to protect the environment but to control the world order in such a way so that it works in its favour and puts the developing countries in a subservient position. A case in point is French policy of nuclear tests in its overseas territories like New Caledonia which is now in headlines for the protests of indigenous people of the island.

There are ample reports that Europe is currently undergoing the tortuous experience of one of the worst waves of climate change vagaries. In Western, Central, and Southern Europe, there has not been any substantial rainfall during summer. In 2022 in particular the continent has seen one of the warmest and driest summers. From Spain to Germany, Italy to Hungary, each country is experiencing the effects of the drought. Furthermore, there is a rising concern that if the dry spell across Europe persists, it would land the Europeans on the deck of the worst drought. So a future out-migration from Europe cannot be ruled out. The drought is also casting a penumbra over the economic recovery of the EU nations which have suffered enormously as a result of the Pandemic.

Important rivers like the Po, which passes through Italy's agricultural and industrial center, have reportedly dried to considerable extent. This means Italy's already-underperforming

[10] See the commentary by Pallak Kashyap entitled "Europe wanted Africa to go green, now suddenly Europe doesn't have money" on https://tfiglobalnews.com/2022/09/27/europe-wanted-africa-to-go-green-now-suddenly-europe-doesnt-have-money/

economy would further go down due to the wrath of Mother Nature. In Hungary, water level on the Danube River has been sinking toward critical level. Furthermore, the late-summer heat wave could have a negative impact on harvests. All these ominous signals suggest that inflation will inevitably augment which is already skyrocketing as a result of the conflict in Ukraine. The post-pandemic and post-war recovery path is now a really tough challenge to accomplish.

According to the EU's Copernicus Atmosphere Monitoring Service (CAMS), the year 2022 recorded the high wildfire activity in south-western Europe [11], destroying tens of thousands of hectares of forest in France, Spain, and Portugal. The bloc's satellite monitoring service indicates France emitted the highest levels of carbon pollution from wildfires. Now after a harsh summer the Europe is probably waiting for a harsh winter. Already signs of drought have begun to pose serious challenge for EU countries. Moreover as the Russian supply is getting shrunk, weakness of solidarity and cooperation within Europe is also becoming conspicuous. As per the report of the Reuters news agency, 'Russia's Gazprom provides a third of Europe's gas, and between 30 and 50 percent of its gas exports to the EU pass through Ukraine'. But since that supply side deal is ruptured, the Netherlands, the EU's largest gas producer, made its position clear that it won't be boosting its share to make up for any loss of Russian gas imports to Europe [12]. Thus it nullifies the cushioning impact of fall of Russian supply of fuel to Europe. With this we notice a marked decline of empathy and conviviality which can be related to the mindset of self-centric modernity and obsession with exclusive self-centric growth perspective through commoditization of nature.

Part-IV

Now we shall briefly delve into the impact of war on people's mindset and how ongoing conflicts, such as the war in Ukraine, can lead to psychological changes within people's mindset. War, with its macabre violence, sound of bombing, shelling, ravaging and loss of life, can gradually desensitize individuals. Here is how it may create a nonchalant mindset:

[11] See https://atmosphere.copernicus.eu/cams-monitoring-extreme-wildfire-emissions-2022

[12] However it may be noted that Russia, according to by Anne-Sophie Corbeau & Tatiana Mitrova of Columbia's Centre on Global Energy Policy, has adopted twin strategies in the aftermath of its Ukraine invasion to remain its pivotal position as the second-largest gross gas exporter in the world, after the US. According to them, Russia "is gradually (and quietly) reshaping its gas strategy based on two expansion pillars: liquefied natural gas (LNG) and pipeline gas exports to key non-EU consumers (Turkey, China, and former Soviet Union [FSU] countries)." (See https://www.energypolicy.columbia.edu/publications/russias-gas-export-strategy-adapting-to-the-new-reality/)

Emotional Numbing: Exposure to prolonged conflict can lead to emotional numbing. Initially, people may react strongly to news of violence or tragedy. However, over time, repeated exposure to distressing events can blunt their emotional balance. They become less sensitive to suffering, loss and trauma.

Normalization of Violence: When war becomes a constant feature of daily life, people may under duress start accepting violence as a normal part of life. The shock factor diminishes, and they adapt to the new reality. This normalization can lead to indifference or even apathy toward ongoing conflicts.

Media Saturation: The constant stream of war-related news, images, and videos, although regulated by the state, can fill the space of social media to cater to war enthusiasts with series of feed. Sometimes the purpose is to sensationalise the issue with excessive supply although a sensitive viewer can always extrapolate the future from limited footage also. But as common people are unaware of commoditization of news in the age of globalization and revolution in ICT, they find it monotonous and emotionally detached, treating war as just another headline.

But the point is how the current conflict has left serious psychological impact on different sections of the Ukrainians. Already the environmental impact is huge and palpable. Here we shall refer to two sources with published data that can be accessed online. One is a post by A. Javanbhakt. He is director of stress, traumas and anxiety research clinic at Wayne State University. He has stressed on three key points viz. i) The Russian invasion of Ukraine may lead to an increased risk of Post-Traumatic Stress Disorder (in short, PTSD), depression, and anxiety among civilians, ii) First responders and veterans in Ukraine are also at very high risk of mental-health consequences, and iii) Ukrainian forces' disproportionate lack of protection and firepower increases the risk of harm, exacerbating mental health consequences [13]. The point to be noted is that Dr Javanbhakt's post was dated March 9, 2022, i.e. even before the full-scale invasion had started. It is obvious therefore that the condition has gone down to a critical nadir by now.

Similarly I would like to take inputs from another research article authored by Philip Hyland et al. It is entitled "Psychological consequences of war in Ukraine: assessing changes in mental health among Ukrainian parents". It was published online by Cambridge University

[13]See https://www.psychologytoday.com/au/blog/the-many-faces-anxiety-and-trauma/202203/the-dire-psychological-impact-russias-invasion-ukraine

Press on April 5, 2023 [14]. Here the key takeaways are: i) Russia's ongoing war on Ukraine has profoundly changed the lives of millions of people, ii) the mental health community has warned of potential long-term negative mental health consequences of this ongoing war, iii) there is evidence that even before 2022, Russia's 2014 invasion of the south and east of Ukraine created a psychological wound and shock, and iv) the full-scale invasion in 2022 has led to serious psychological harm among the population. In this study, the authors have reported on changes in anxiety, depression, loneliness, and hazardous drinking following the 24 February 2022 invasion. Its findings were significant such as increases in anxiety, depression, and loneliness which were found to be higher for women, while increases in hazardous drinking were higher for men in Ukraine. The study also indicated that "the disruption to normal life brought about by the war may be disproportionately affecting younger people." The authors "also found regional differences with those living in the west, centre, and south of Ukraine reporting more pronounced changes in their mental health compared to those living in the north. It is difficult to know why this might be but it is possible that living in the north of the country – which includes the strongly fortified capital city of Kyiv – offered a greater sense of protection and safety." This finding can be compared to the urge for return among the majority of displaced Ukrainians. This is according to a press release at July 10, 2023 by the Office of the UN Resident Coordinator stationed at Kyiv, Ukraine. It spoke of both hope and intention to return as expressed by the Ukrainian refugees. To quote the press release Mykolaiv, Chernihiv, Kyiv and Kharkiv regions, as well as Kyiv city, were identified among the top areas of intended return. Obviously there are various reasons and factors as enablers facilitating voluntary return, but given the condition of ongoing conflict and active combat, it can be said that the return of Ukrainian migrants does not necessarily indicate that they have become "used to" the situation or its risks. Instead, it reveals several psychological dynamics like mental resilience and adaptability. They navigate the complex interplay of fear, hope, and attachment to their homeland. Even there is high possibility that their decision to return involves conflicting emotions in which fear of danger coexists with a longing for stability and a desire to contribute to Ukraine's recovery. On the whole, their urge for return movement for homeland reflects a complex interplay of emotions, attachment to land and resilience.

[14] https://www.cambridge.org/core/journals/psychological-medicine/article/psychological-consequences-of-war-in-ukraine-assessing-changes-in-mental-health-among-ukrainian
parents/562739926FFE97C61B22F5C90D47D531

Concluding Observations

We do not know when this conflict will come to an end or how much time will be required to neutralise the landmines planted at different theatres or whether it will linger more when people will respond in their own ways to the harsh realities. But there is hardly any disagreement that Ukraine will need at least two decades to recover from toxic effects of the war. Even the point is not narrowly specific to the limited war zones but the impact in all probability will be pervasive and taxing for the entire Europe and its multiple spill-over impact ranging from pollution, impact on soil, vegetation, and most acutely worsening the mental health front. Taken together it seems to be an uphill task at the moment but in the long run it can prove to be another conundrum if people deeply upset by such statist monopoly to war making, rise in revolt against sovereignty. Those days are not far away when sentient beings would claim the right of humanity's convergence and harmony with nature than the political tutelage of the state.

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[3] See the Press Release by the US Treasury on Feb 24, 2022 https://home.treasury.gov/news/press-releases/jy0608

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[12] https://atmosphere.copernicus.eu/cams-monitoring-extreme-wildfire-emissions-2022

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[14] See the article psychological consequences of war in Ukraine: assessing changes in mental health along Ukranian parents on https://www.cambridge.org/core/journals/psychological-medicine/article/psychological-consequences-of-war-in-ukraine-assessing-changes-in-mental-health-among-ukrainian parents/562739926FFE97C61B22F5C90D47D531

Research Article

Anekārthā hi dhātavaḥ: how far is it compatible?

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Abstract: Dhātu is the base of the words, and it added with nominal endings implies prātipadika. Being associated with tiṅ, it expresses verbs and sometimes indicates its own meaning without any addition of a suffix. Although around two thousand roots have been listed in the Pāṇinīya Dhātupāṭha, the actual application of more than half of these roots is not seen in Sanskrit. To what extent this interpretation of the roots and multiple meanings is acceptable is discussed here in this paper. The objective of the paper is also to find out the reason behind this plentiful meaning of roots.

Keywords: verbal root, *dhvārtha* (the meaning of root's), Pāṇinian *Dhātupāṭha*, numerous meanings, various reasons.

Introduction:

Dhātu (verbal root) is the essential ingredient of words, and it is also mentioned that the verbal root *(dhātu)* is the basic unit to which suffixes are added. The word '*dhātu*' is derived from the root *dhā* (to lay, put) and the derivation of it's, *'abhidadhātyarthaṃ dhātuḥ iti'*√ḍudhāṃ + tun>dhātu. Nirukta provided the etymological meaning of it, thus, *"etāvantaḥ samānakarmaṇo dhātavaḥ dhāturdadhāteriti"* [1]. Pāṇini did not define the term *dhātu*, but he used it three times in his *Sūtrapāṭha*, in the heading rule '*dhātoḥ'* [2]. Again, in Aṣṭādhyāyī, the aphorism *'bhūvādayo dhātavaḥ'* indicates that *bhū* and so on are roots. The great commentator Patañjali has explained this sutra, '*kriyāvacanoḥ dhātuḥ'* or *'bhāvavacano dhātuḥ'* [3]. Actually, the root is transformed into a verb with a verbal ending, *tiṅ*. And the meaning of suffixes that occur in the latter of this root is tense, number, syntax, etc. The verb refers to the sum of all processes from the beginning of the work to the end. Now the indivisible element that expresses the original meaning of that verb is Dhātu, or root. Therefore, the *Prakṛti*, or base, of the verb is the root.

It is notable that the word cannot be termed dhātu unless it is included in the *Dhātupāṭha* (enumeration of roots). That's why it is said in Śabdakaustubha, '*kriyāvācino gaṇapaṭhitā dhātusaṃjñāḥ syuḥ'*[4]. Otherwise, due to the verbal sense, indeclinable words like hiruk etc. will be defined as *dhātu*. Though around two thousand roots have been counted in the *Pāṇinīya Dhātupāṭha*, the actual application of more than half of these roots is not seen in Sanskrit.The Modern Scholar Whitney clearly demonstrates that "it may be added that of the more than 800 roots here recorded as making forms of conjugation, nearly 200 occur only in the early language, nearly 500 in both earlier and later and less than 150 only in the later" [5].

Objective and method of the Paper:

This paper is analytic in nature. Here I do a brief survey on verbal roots, the meaning of roots and various meanings of roots. The objective of the paper is to find out whether the multiple meanings of the root's are acceptable or not. Here also an inquiry is set about to find out the reason behind these multiple meanings of root's.

Dhātvarthaḥ **(**the meaning of Root's**):**

It was said before that the root carries the meaning of an action. So the meaning of the root is *'vyāpāra'* (process) and '*phala'* (result). In Sanskrit, the root is the base of a verb. Nairuktā thinks that, not only verbs, the root is the base of all words. This is stated by Patañjali in Mahābhāṣya –*'nāma ca dhātujamāha nirukte vyākaraṇe śakaṭasya ca tokam'*. The ancient Grammarian Nāgeśabhaṭṭa also thinks that the verbal root is the source of all words [6]. The Grammarians, Mīmāṃsaka and Naiyāyika, also made comments concerning the root's meaning. A brief discussion is made here on root meanings in the light of the philosophy of Grammar.

Nāgeśabhaṭṭa takes the meaning of the root's as '*phalaviśiṣṭavyāpāra'* and *'vyāpāraviśiṣṭaphala'* [7]. Here, the Process or *Vyāpāra* indicates the sense of an action. In the view of Manḍanmiśra, 'Result' is the meaning of root's and 'Process' is '*Pratyayārtha'* [8]. While Ratnakośakāra thinks, the meaning of root is 'Process' and the meaning of *Ākhyātārtha* is '*Utpādanā*', i.e., *Vyāpāra, Utpādanā* and *Bhāvnā* are synonymous [9]. This action can be multiple and these

multiple actions cumulatively form an action called *kriyā* [10]. Now the process produces the result of this action, which is termed the Result, or Phala. So, the simple meaning of Result or Phala is 'the objective of a verb'. It is used in the sense of the completion of an action. For example, the result of the root '*pac'* is *'viklitti'* (meltness), the root '*han'* is 'demise', and the root '*gam'* means 'country division'. The meaning of the root's doesn't change wherever the root is added with a suffix or its various formations.

Every Grammarian instructed roots with meaning in their *Dhātupāṭha*. Though it is debatable about the authorship of Pāṇini for his *Dhātupāṭha*. Again, the meaning of root entries is also debatable. Some scholars think, the Grammarian Bhīmasena instructed the meaning of the root's of Pāṇinian *Dhātupāṭha*. Though renowned modern Scholar Yudhishthira Mimamsaka doesn't think so. He proved it that the meaning of roots was made by Panini himself, not anyone else. He also mentions the two versions of Pāṇinian *Dhātupāṭha* i.e., *Vṛddhapāṭha* (with meaning) and *Laghupāṭha* (without meaning). At present, the various commentary texts are available and they contain the roots with meaning in Pāṇinian *Dhātupāṭha*. The roots, which read into *Dhātupāṭha*, contain single, double or more meanings at a time. Modern scholar Bronkhorst observed and shared the information about the root's which read with single meaning in Pāṇinian *Dhātupāṭha* and also those roots which have two or more meanings i.e., total number of roots existed in Pāṇinian *Dhātupāṭha* with single meaning - 964, double meanings - 243 roots, three meanings- 99 roots, four meanings- 25 roots, five meanings- 16 roots, six meanings- 4 roots, seven meanings- 2 roots, eight meanings- 1 root, eighteen meanings-13 roots etc.[11]. For example,

bhū sattāyām (single meaning)

kruśa āhvāne rodane ca (double meaning)

dibu krīḍā-vijīṣāvyavahāra-dyuti-stuti-kānti-moda-mada-svapna-gatiṣu. (Roots with a plentiful meaning)

Anekārthā hi dhātavaḥ (Plentiful meanings of root's)

The multiple meanings of roots are seen everywhere. Now the question arises: is it acceptable or not? To give the answer, we should go back to the Pre-Pāṇinian era. If we notice

the most popular *Kāsakṛtsnaśabdakalāpa Dhātupāṭha*, then we find that it is clearly mentioned there; roots are read with numerous meanings. For example, ten meanings of *bhū dhātu* are listed there, like as,

"sattāyāṃ maṅgale vṛddhau nivāse vyāptisampadoḥ/

abhiprāye ca śaktau ca prādurbhāve gatau ca bhūḥ//

On the other hand, it is stated at the end of *Cāndra Dhātupāṭha*, i.e.,

kriyāvācitvamākhyātumekaiko'rthaḥ hi pradarśitaḥ/

prayogato'numantavyā anekārthā hi dhātavaḥ // [12]

The meaning of *Ākhyāta,* i.e., verbal root, is expressed here. At the same time, it is clearly attested at the end of *kārikā* by the term '*anekārthā hi dhātavaḥ'* that the Cāndra School of Grammar accepts the plentiful meaning of roots. On the contrary, 'the single root with single meaning' formula is also available there. Again, Patañjali also gave the statement many times at many places, i.e., '*vahvārthā api dhātavo bhavanti'*. [13] Moreover, this type of comment is also seen in other places, like '*dhātūṇāmanekārthatvam'*. In this context, the rule, *'vahulametannidarśanam'* (10/392) is also remarkable. The above-mentioned aphorism mainly refers to *Curādi* [14] roots. Here, the word *'bahula'* indicates uncertainty or irregularity. Kṣīrasvāmī opined, Saunāga Grammarian explains the aphorism against the plentiful meaning of root's. Kalījivan Devaśarmā has stated that the numerous meanings of roots are almost applicable. He also repeats, here *'prayoga'* means '*śiṣṭa-prayoga'*. Contextually, the commentator Kṛṣṇalīlāśuka made a comparison of that usage with God. Again, the Commentator Goyīcandra also remarked in the context of Cāndra Dhātupāṭha's statement like, '*anekārthā hi dhātavaḥ'* as *'dhātuṇāmanekārthatveneṣṭasiddhimabhyupagantuṃ candra eva paraṃ paramapaṇḍitaḥ.* [15] In the context of the rules 10/392, G. B. Palsule stated, 'It is the actual usage of the language which determines the expressive power of a root'.

Conclusion

Considering Grammarians usage of their own contribution to Sanskrit Grammatical Literature from the Pre-Pāṇinian era to the Post- Pāṇinian, it is easily perceived that a root with

numerous meanings is acceptable and those applications are also accepted. The various factors are responsible for the different meanings of roots, such as social implications, historical aspects, community, division of countries, time frame, influence of colloquial language, etc. According to Kṣīrasvāmī, the meaning of root's varies due to the division of the country and this is one of the reasons for the difference in meaning of root's- "*tattaddeśādi prasiddhārthānāṃ pṛthaṅnirdeśaḥ*" [16]. Finally, it is well known that Pāṇini composed his Vyākaraṇa with the aim of preserving the Sanskrit language at the juncture of the Vedic and Classical periods. The later Sanskrit Grammarian was to make the seemingly monotonous Grammar acceptable to all. This effort is also noticeable in the case of *Dhātupāṭha* texts. Subsequent *Dhātupāṭha* texts have been found to refer to roots in a very simple conversational language. In most of the cases, it was seen that they rejected the traditional meaning of roots and accepted the spoken Sanskrit language.

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[3] F. Kielhorn. *Mahābhāṣyam*. 1st vol., Bombay: Government Central Book Depot. p.336.

[4] Gopal Sastri Nene. (Ed.) *Śabda Kaustubha* 1.3.1 edited by, Vol. II, 1985, p. 49

[5] William Dwight Whitney, *The Roots, Verb and Primary Derivatives of Sanskrit Language*. Index, p. 243

[6] *Pramalaghumañjuṣā, dhātvarthavicāra*

[7] *tatra phalānukūlo yatnasahito vyāpāro dhātvarthaḥ -Pramalaghumañjuṣā*

[8] *phalaṃ dhātvartho vyāpāraḥ pratyayārthaḥ -Manḍanmiśra*

[9] *vyāpāra bhāvnā saivotpādanā saiva ca kriyā*- vi.si.kau.5

[10] *vyāpāraḥ bhāvayiturutpādanakriyā*

[11] Johannes Bronkhorst. "*Meaning Entries in Pāṇini's Dhātupāṭha."* Journal of Indian Philosophy. 1981, p. 337

[12] *Cāndra Dhātupāṭha*

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[15] *tiṅ, 730*

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Review Article

Taming the Oil Spill Through Bioremediation

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~~Abstract~~: Oil spills present a pressing environmental challenge with far-reaching ecological and economic consequences. Traditional clean-up methods often fall short in addressing the complex and pervasive nature of these disasters. Bioremediation, a sustainable and eco-friendly approach, harnesses the power of naturally occurring microorganisms to degrade and eliminate oil contaminants from aquatic ecosystems. Bioremediation of marine oil spills has become a very practical approach to oil spill cleanup efforts in recent years. Therefore, the principal aim of our review study is to explore the transformative potential of bioremediation in mitigating oil spills and the importance of on-going research and innovation in the field of bioremediation, emphasizing its role in shaping a more resilient and sustainable future in the face of oil spill emergencies. Furthermore, our study tries to focus on a glimpse into the promising avenues of bioremediation, showing its capacity to tame the destructive impact of oil spills and restore the balance of fragile marine ecosystems.

Keywords: Biostimulation, Bioaugmentation, Hydrocarbons, Exxon Valdez

Introduction:

Human activity has led to the release of liquid petroleum hydrocarbon (also known as crude oil) into the environment, causing the pollution of marine/coastal waters, shorelines and land as well. Marine oil spills are very catastrophic events which pose a great threat on the affected environment. Although it is often believed that oil spills affecting marine environments are primarily the result of large oil tanker spills such as the Exxon Valdez incident, most of the oil contamination that occurs is due to surface runoff, the transportation of oil, port activity, and illegal bilge water discharges [1]. Oil is comprised of many different toxic compounds which endanger the natural habitat. However, there are many natural, native microorganisms which are not only capable, but thrive on the decomposition of these toxic compounds. This process of using microorganisms for such clean-up efforts is known as bioremediation and this has proven to be a successful method for the clean-up of marine areas affected by oil spills [2].

Oil spill causes so many troubles both to the ecosystem and to the animal, especially the oil floats on the water and prevent the sunlight to pass through, which kills the plants and animals which need sunlight. The oil can also clog the blowholes of the whales and dolphins, leading to suffocation and death. Seabird's feather gets sticky and heavy, making them unable to fly. It destroys the insulating ability of fur bearing mammals, leading them to die out of cold. Animals and birds might get poisoned if they consume the oil.

The methods currently used to remove the oil from ocean are either too expensive or catastrophic; including burning the oil is cheaper but may kill millions of animals beneath the

fire. Other traditional methods of oil spill clean-up include using mechanical devices such as skimmers and oil booms. However, these techniques are laborious and generally costly.
But interestingly a group of bacteria can help us to sort out this issue. They are known as Oil-eating bacteria and the method is called Bioremediation. It is found that combining the traditional approaches with bioremediation can allow for a much more successful clean-up process while also reducing cost, as well as man hours. Research has been conducted and is still underway, regarding how these different parameters affect bioremediation and its practicality. Research, as well as actual applications to marine oil spills, has shown that bioremediation has many advantages and great potential for many different oil spill cases, however there are also disadvantages, making bioremediation not the best method of clean-up for all marine oil spills. Therefore, the principal aim of our review study is to explore the transformative potential of bioremediation in mitigating oil spills and the importance of on-going research and innovation in the field of bioremediation, emphasizing its role in shaping a more resilient and sustainable future in the face of oil spill emergencies. Furthermore, our study tries to focuses on a glimpse into the promising avenues of bioremediation, showing its capacity to tame the destructive impact of oil spills and restore the balance of fragile marine ecosystems. Consequently, this study is intended to identify the main challenges associated with the use of bioremediation to clean-up crude oil pollution in both terrestrial and marine environments, and also to develop recommendations, which are likely to form the basis for new lines of research on how to overcome these challenges.

The Fate of Spilled Petroleum Hydrocarbons:

Fundamental variation exists in the manner in which crude oil behaves when spilled on land and water. Oil spilled on the sea surface undergoes various weathering processes simultaneously, such as spreading – influenced by wind, turbulence and the presence of ice on the water surface [3], evaporation, emulsification, photo-oxidation, dispersion, sinking, resurfacing, tar ball formation, and biodegradation – which makes oil spill control very difficult [4]**.** Hence, the extent of the damage caused by the spill and the ease of clean-up depends on how quickly the clean-up response takes effect. The kinetics of these processes depends largely on sea conditions and the meteorological environment. In addition, the rate of natural weathering of the spilled oil on land largely depends on the exposed surface area of the spill and slows down over time compared to water oil spills where crude oil thins to a thickness of a few millimetres as it spreads extensively. Light crude oil components (such as alkanes) leach into the soil depending on the soil porosity and permeability or may evaporate rapidly based on favourable atmospheric conditions. Heavy crude oil components (such as asphalthenes), on the other hand tend to be retained at the surface due to their higher viscosity and thickness. Oil spill stability is usually a land phenomenon and it occurs within a short period of time with the gradual stoppage of further weathering. This rarely occurs in marine oil spills, probably as a result of the dynamic nature of the marine environment.

Ecological Impacts of Spilled Petroleum Hydrocarbons:

Both land and marine ecosystems suffer from the impact of oil spills in similar ways. The impact on living organisms could either be direct, indirect or acute (short-term) and chronic

(long-term). Direct impacts include suffocation (clogging of the lungs, nasal passages or oxygen-exchange sites), anoxia (thick oil slicks on the surface inhibit oxygen from dissolving in ocean waters), and inhibition of movement of animals within the soil, river or ocean due to the viscous nature of crude oil. Indirect impacts, on the other hand, include stunted growth (in both plant and animal forms), reproductive and morphological deformities and trophic cascades[5].

The short-term impacts include acute narcosis mortality, acute exposure of feathers and fur causing hypothermia, smothering, drowning and ingestion of toxic compounds during preening, whilst the long-term impacts include exposure of embryos to weathered oil, ingestion of contaminated prey or foraging in polluted sedimentary pools and the disruption of important social functions (such as caregiving) in gregarious species **[5]**. Oil spills in marine habitats affect mostly marine birds (diving birds in particular) and fishes, rendering them vulnerable to the adverse effect of petroleum pollutants [4]. However, the chemical dispersants used to control the spill have been found to be very harmful and, in some cases, kill shellfishes [4]. The environment near a petroleum refinery or a tanker terminal is exposed to chronic oil pollution from frequent spills and from the continuous discharge of contaminated process water [6**]**. In some cases, a high frequency of both cancerous and non-cancerous disease of fish and shellfish has been detected in severely polluted sites [7].

Oil spills in third-world countries often have a much larger impact on the environment and human lives compared to oil spills in the developed countries, probably due to the insufficient infrastructure or technologies for controlling oil spills. Other factors include the higher number of uneducated citizens who are not enlightened about the potential impacts of oil spills and the weak environmental laws in third-world countries, which if strengthened, would control the activities of oil drilling firms. For example, in the Bodo community and the Ogoni land of the Niger Delta region of Nigeria, Shell Petroleum massively spilled several million barrels of oil in 2009, polluting farmlands and groundwater via land pits or wells [8] . The crude oil in groundwater ended up in nearby rivers, killing aquatic life and disrupting fishing activities, the only means of livelihood in the rural area. This massive spill also prevented the fetching of clean water from streams for domestic use by the inhabitants of the rural community. Some of the villagers still go to the polluted rivers to fetch water, as they are ignorant of the consequences of their actions, thereby increasing the impact on human health via ingestion, inhalation and contact with the skin [9]. Post-spill ecological impacts are more severe when oil spill clean-up measures are not executed on time, compared to the impact during a spill. There is also possibility of the concentration of pollutants in living tissues, which is known as bioaccumulation. This could be taken up by other animals through ingestion, leading to the transfer of toxic hydrocarbon compounds up the food chain. It is a consequence of long-term pollution from crude oil [10].

Crude oil bioremediation strategies:

Bioremediation is defined as the use of natural microorganisms, plants, or fungi in the correction of a contaminated or altered environment (Table 1). Oil spill clean up is either undergone by bioaugmentation or biostimulation strategies to improve the effectiveness of bioremediation process.

Table 1: Representative microorganisms capable of degrading petroleum hydrocarbons [11,12,13]

Bacteria	**Yeast and Fungi**
Achromobacter	*Aspergillus*
Acinetobacter	*Candida*
Alcaligenes	*Cladosporium*
Arthrobacter	*Penicillium*
Bacillus	*Rhodotorula*
Brevibacterium	*Sporobolomyces*
Cornybacterium	*Trichoderma*
Flavobacterium	
Nocardia	
Pseudimonas	
Vibrio	

Biostimulation is an in situ bioremediation strategy that involves the supply of nutrients (mainly nitrogen and phosphorus) to hydrocarbon-polluted sites in order to "stimulate" the indigenous micro-organisms to break down more crude oil [14, 15]. The justification for the use of this bioremediation strategy is that hydrocarbon metabolism is limited by nutrient availability; therefore, by supplying the required nutrients microbial degradation of hydrocarbon is expected to increase. This strategy is compatible with land and the aquatic environments. The nutrients supplied could be from organic or inorganic sources. Biostimulation has been widely accepted to degrade alkanes [16] and PAHs [17] and also is regarded as cost-effective [18] because it does not require the excavation of polluted soils or the transfer of polluted water to a treatment facility. However, high concentrations of nutrients applied to the environment may lead to eutrophication [19] usually in aquatic environments. Eutrophication has been reported to cause algal bloom, oxygen depletion or may even induce toxic responses in humans and the marine ecosystem [20]. This has led to the need to test the safety levels of nutrients applied in bioremediation.

EXXON VALDEZ – A case study of bioremediation of oil spill

The Exxon Valdez catastrophe occurred in 1989, after the tanker hit the Bligh Reef which is located in Northern Prince William Sound. This accident resulted in the tanker dumping 20% of its Prudhoe Bay Oil, 42 million litres, into the sea off the coast of Alaska. This enormous amount of oil spread along the coast, contaminating more than 1900 km of shoreline [21]. This had a horrific effect on the natural habitat involved and resulted in the death of numerous animals. The clean-up process for this spill had many complications due to the remoteness of the location which only allowed access for boats and helicopters [22].

The first stage of clean-up following the Exxon Valdez spill was the use of burning the oil and a fire-resistant boom. This method however, was quickly abandoned due to rough weather. Following the attempt to burn the oil, mechanical methods were tried with the use of a skimmer and boom. This method was also unsuccessful due to the nature of the oil which was very dense and easily clogged the skimmers. The density of the oil also created problems

and difficulties in transferring the collected oil. As well as using mechanical methods, chemical dispersants were also used for clean-up. Like the previously attempted methods, dispersants were also unsuccessful. This controversial method failed due to the lack of waves needed in order to provide proper mixing of the chemicals with the sea, researchers from the EPA (United States Environmental Protection Agency) felt this situation was an ideal scenario to try bioremediation. Although there had been very little experience at this time with bioremediation, experts decided that "the Alaska oil spill situation should be treated as a laboratory to increase the nation's knowledge and readiness for action in future oil spills" and the use of fertilizers should also be utilized. It was known that there were indigenous hydrocarbon degrading microorganisms present in Prince William Sound, and after the oil spill it was found that there was a 10,000-fold increase in the number of these microbes in the areas that were affected by the spill.

The use of bioremediation was proven to be effective with the Exxon Valdez spill and within 10 to 14 days after the application of nutrients there was a noticeable difference in the reduction of oil on the sites which had biostimulation, compared to those which were not treated. This showed that using bioremediation not only worked at cleaning up the oil, but it also worked very quickly. With the success of bioremediation after the first summer of its use, the EPA then supported further use of bioremediation on the contaminated beaches and after more research, the EPA declared it a safe method of clean-up for marine oil spills.

Factors affecting bioremediation:

The conditions of the contaminated area plays a major role on whether bioremediation is the appropriate method of clean-up for the given oil spill. The success of bioremediation is dependent upon physical conditions and chemical conditions. Physical parameters include temperature, surface area of the oil, and the energy of the water. Chemical parameters include oxygen and nutrient content, pH, and the composition of the oil. Temperature affects bioremediation by changing the properties of the oil and also by influencing the oil degrading microbes [23]. When the temperature is lowered, the viscosity of the oil is increased which changes the toxicity and solubility of the oil, depending upon its composition[24]. Temperature also has an effect on the growth rate of the microorganisms, as well as the degradation rate of the hydrocarbons, depending upon their characteristics.

Appropriate levels of oxygen, nutrients and pH are factors which will directly influence whether or not the microorganisms are capable of surviving in the environment. Oxygen is required for the survival of many microorganisms and also drives the reactions for the degradation of the hydrocarbons. The necessary nutrients, particularly nitrogen and phosphorus are also needed for the growth of the microorganisms and also for the conversion of the excess carbon present from the oil. The chemical composition of the oil is another parameter which affects whether bioremediation is a possible alternative. Unlike many of the other requirements needed for successful bioremediation, the chemical composition of the oil is a factor which cannot be altered. If the oil is a heavy crude oil which contains resins and asphaltene compounds, it is very difficult for microorganisms to degrade compared to lighter crude oils [25].

Advantages:

Bioremediation has many advantages over traditional clean-up methods of marine oil spills. One of the major advantages of bioremediation is the savings in cost and also the savings in the time put forth by workers to clean a contaminated site. The financial savings of bioremediation, when used properly, have tremendous benefits compared to traditional clean-up processes. After the Exxon Valdez catastrophe for oil spill, the cost to clean 120 km of shoreline by bioremediation was less than cost to provide physical washing of the shore for one day. Another way that bioremediation allows for savings is that unlike traditional methods, bioremediation continues to clean the contaminated site without the constant need of workers. This saves a great deal of money which would be spent on labour hours and it also allows for time to be spent performing further research on bioremediation.

Bioremediation is also advantageous due to its environment friendly approach. Unlike chemical methods, no foreign or toxic chemicals are added to the site. It is also environment friendly because it does not require any disruption to the natural habitat which often occurs from physical and chemical methods of clean-up. Bioremediation allows for natural organisms to degrade the toxic hydrocarbons into simple compounds which pose no threat to the environment and this also eliminates the need to remove and transport the toxic compounds to another site. This loss of a need to transport the oil and contaminated soils lowers further risk of additional oil spills and also saves energy and money which would be put forth in the transportation process. These environmental benefits also make bioremediation a positively viewed method by the general public. With the limited resources in today's world, this is a very much supported technology, which pleases the public and hence is given political support and funding for further research.

Disadvantages:

One of the greater downsides of bioremediation for marine oil spills is that it is a slow process. Oil spills can pose a great threat to many different habitats, environments and industries, and depending upon the urgency of clean-up, bioremediation may not always be the best available option. Also there are many variables that affect whether bioremediation is capable and practical for the clean-up of different oil spills. Depending on where the spill takes place and the conditions of the water there, it may be very difficult to provide proper nutrient concentrations to the oil degrading microorganisms. If an oil spill occurs offshore, there is typically much more energy and waves, and this can cause for the quick loss and dilution of nutrients provided by biostimulation. In the case of bioaugmentation, there are problems which occur, particularly the competition that will develop between the native and foreign microbes, making this an unsuccessful method of bioremediation. Another disadvantage of bioremediation is that it is a very difficult process to conduct field tests on. This is due to many factors and conditions which cannot be controlled in the field, but only in laboratory tests.

Conclusion:

Bioremediation has proven to be a successful secondary method of treatment for marine oil spills when followed by traditional physical cleaning methods. It is capable of being used as the sole treatment method in the certain cases where clean-up of the oil is not a great urgency and if the oil is not a free product. Being a newer technology, there is still much research to be conducted examining the benefits, limitations and capabilities of bioremediation use for marine oil spills. The Exxon Valdez oil spill, although very tragic and devastating, shed much light on the possible benefits of bioremediation and also influenced much further research on the technology. The Exxon Valdez spill also made aware the need for improvement on further prevention of marine oil spills which resulted in congress passing the Oil Pollution Act of 1990, which strengthened regulations on oil tankers, as well as their owners and operators. The Delaware Bay field study was another very valuable research opportunity on bioremediation and this brought about a much greater understanding on the effectiveness of this technology, as well as its practicality.

Concerning the two methods of bioremediation, bioaugmentation and biostimulation, biostimulation is the more effective approach to take. Bioaugmentation does not allow for any greater growth of microorganisms or degradation of hydrocarbons than biostimulation alone, when there is already an indigenous oil degrading microorganism in the affected site. Depending upon the concentration of the already present natural nutrients at the site, biostimulation can have a dramatic effect on the growth rate of the hydrocarbon degrading microorganisms which allows for an inexpensive clean-up method at a much more accelerated rate than natural biodegradation alone.

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Review Article

Outer Membrane Vesicle (OMV): A Potential Vaccine Against *Vibrio cholerae*

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Abstract: Cholera is one of very infectious and lethal disease in developing countries like India which get transmitted through contaminated water causing rapid fluid loss from body, imbalance of ion and organ failure.There are many vaccine against cholera but due to low efficacy and shorter duration of coverage, scientists are in search for an ideal vaccine with high efficacy and lower reactogenicity. Outer Membrane Vesicle (OMV) based vaccine of cholera which are created from outer vesicles of *Vibrio cholerae* itself, meets all these required necessities. These vaccine may provide a giant leap in eradication of cholera caused by different type of strain of *Vibrio cholerae*.
Keywords - Cholera, Outer Membrane Vesicle (OMV), vaccine, reactogenicity, *Vibrio cholerae*.

Introduction

The word cholera earlier known as Cholendra means "The Gutter of the Roof".Cholera was derived from the Greek word chole which means bile. In Latin vibrio means "to quiver" or to shake with a slight but rapid motion and cholera means bilious disease [1]. According to WHO, cholera causes an acute diarrhoeal infection by ingestion of food or water contaminated by the bacterium *Vibrio cholerae*.

Cholera was first observed by Filippo Pacini during the 1854 cholera outbreak in Florence, Italy, and he documented that the cause of the infection was a bacterium. It was after 82 years of death of Filippo Pacini, the International Committee on Nomenclature in 1965 adopted *Vibrio cholerae* Pacinias as the correct name of the cholera-causing organism [2,3]. The discovery of Cholera Toxin (CT) by Dr. Sambhu Nath De in 1959, as a cause of pathogenicity of *Vibrio cholerae* paved the way for the best studied pathogen at the molecular level [4]. A gram negative, comma shaped motile bacterium which belongs to Vibreoneceae family of bacterium kingdom.

Cholera pandemic-causing *V. cholerae* strains are mainly O1 and O139 serogroups which arose from the Indian subcontinent. *V. cholerae* O1 has two major biotypes, **Classical and El-Tor** [5].

According to WHO, each year around 30000 to 120000 people die due to cholera infection. Cholera symptoms ranges from mild diarrhea to cholera gravis (severe cholera) resulting in sunken eyes and decreased skin turgor. In developing countries like India where clean drinking water is still not accessible to all, it remains a grave threat to health system.

According to a study by Indian Integrated Disease Surveillance Programme (IDSP), cited that over 400 million people could be considered as at risk of cholera in India. Of those at risk, 675,188 cases were likely to occur, resulting in 20,256 deaths (3%) annually.

IDSP attempted to identify the districts demanding greater attention despite their non-endemic status. Nineteen of 685 districts (2.8%), spread over seven States/Union Territories (Chandigarh, West Bengal, Kerala, Karnataka, Gujarat, Punjab and Haryana) were defined as endemic. The map (Fig 1) depicts the state wise distribution of these districts. Seventeen (89 %) of these 19 endemic districts along with 34 other districts (non-endemic) reported multiple (two or more) cholera outbreaks in a year during this five-year period of 2011-2015 [6].

Fig 1 - Cholera Endemic Districts of India

Cholera infection starts after ingestion of food or water contaminated by *Vibrio cholerae* (O1 and Q139 strains). Cholera infection usually requires ingestion of a large inoculum, between 108 and 1011 viable organisms to produce disease consistently in adults. [6]. As most *Vibrio cholerae* are killed in the acidic gastric environment and the required inoculum gets decreased in individuals with such gastric acidity.

Mechanism of action of Cholera Toxin (CT) and Toxin Coregulated Pilus (TCP)

Once *Vibrio cholerae* reaches the intestine, it is propelled by a single sheathed flagellum. thereafter it penetrates the mucus barrier to adhere to the small intestinal mucosal surface of the individuals. Motility is significant for successful colonization. In animal models of cholera, *Vibrio cholerae* preferentially colonizes the mid-small intestine to the distal small intestine, with

normal pH where it forms clonal microcolonies in villous crypts. The presence of mucus, bile, and other external signals activate the ToxR regulon, a signaling hub which controls virulence through the expression of CT and the toxin-coregulated pilus (TCP). All cholera-causing strains of *Vibrio cholerae* harbor the ToxR regulon and the machinery to secrete both factors Toxin Co- regulated Pilus (TCP) and Cholera Toxin (CT). TCP a long, flexible type IV pilus that helps in colonization. It is made up of a repeating configuration of TcpA, the main structural subunit [7].

TCP helps in biofilm formation, self-aggregation, bringing the bacteria together in microcolonies that protect them from host defenses and concentrate their secreted cholera toxin. Cholera Toxin an AB 5-subunit toxin, composed of one enzymatically catalytic A subunit (CtxA) and a pentamer of B subunits (CtxB) [7]. The B subunit pentamer binds the monosialoganglioside GM1 via cell surface receptors on the apical surface of the epithelium of small intestine in individual. CtxA is then free to bind with a human partner protein called ADP-Ribosylation factor 6 (ARF6), binding to ARF6 drives a change in the shape of CtxA which exposes its active site and enables its catalytic activity. The CtxA fragment catalyzes ADP ribosylation of the Gs alpha subunit($G\alpha_s$) proteins using NAD (Fig 2).

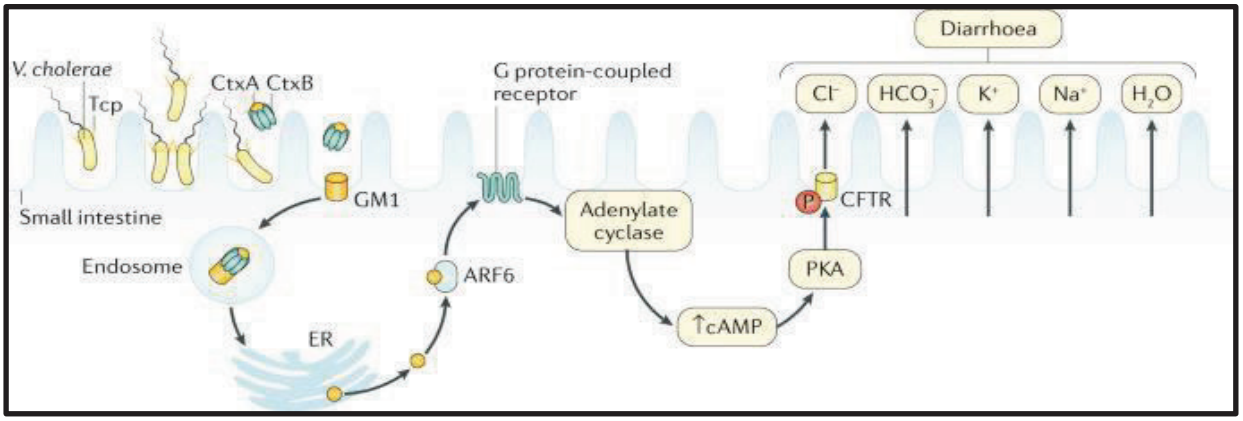

Fig 2- Mechanism of Cholera Toxin (CT)

The ADP-ribosylation causes the $G\alpha_s$ subunit to lose its catalytic activity of GTP hydrolysis into GDP + Pi, thus maintaining $G\alpha_s$ in its activated state. Increased $G\alpha_s$ activation leads to increased Adenylate cyclase activity, which increases the intracellular concentration of 3',5'-cyclicAMP (cAMP) to more than 100-fold over normal and over-activates cytosolic PKA. These active PKA then phosphorylates the Cystic fibrosis transmembrane conductance receptor (CFTR) chloride channel proteins, which leads to ATP-mediated efflux of chloride ions (Cl^-) and leads to secretion of H_2O, Na^+, K^+, and HCO_3^- into the intestinal lumen. In addition, the entry of Na^+ and consequently the entry of water into enterocytes are diminished.

The combined effects result in rapid fluid loss from the intestine, up to 1 liter per hour which leads to severe dehydration. In severe cholera, the disruption of intestinal homeostasis lasts for up to 6 months, much longer than the diarrheal symptoms of cholera, which usually resolve within an

average of 2 to 4 days depending on antibiotic treatment. There are many ways to detect cholera in patients like through stool culture and blood tests [8]. These patients are treated with intravenous fluids, zinc supplement and with antibiotics like tetracycline. As we know prevention is better than cure, supply of clean drinking water and vaccination are the most approached way to prevent cholera [9]. Present day cholera vaccine has been reported to be less effective with short duration of protection and unacceptable rate of side effects. But at the end of tunnel, there is a ray of light, where OMV based vaccine of cholera, which meets all required necessities of an effective vaccine as they are derived from outer vesicles of cholera bacteria, a miracle of scientific advancement. Although these vaccine is still in trial phase, it's implications are noteworthy.

Outer Membrane Vesicle- A Pioneer Candidate for Vaccine of *Vibrio cholerae*

Outer membrane vesicles are nanosized (from 20 nm to 200 nm) proteo liposomes derived from the outer membrane of Gram-negative bacteria and sometimes by Gram positive bacteria. They are ubiquitously produced during culture and during infection. They play crucial roles during host-microbe interactions and act as mini bacterium which helps in host microbes interaction (Fig 3). In 1967 Chatterjee and Das discovered OMVs in a study conducted on the cell wall of *Vibrio cholera* using Transmission-electron microscopy [10].

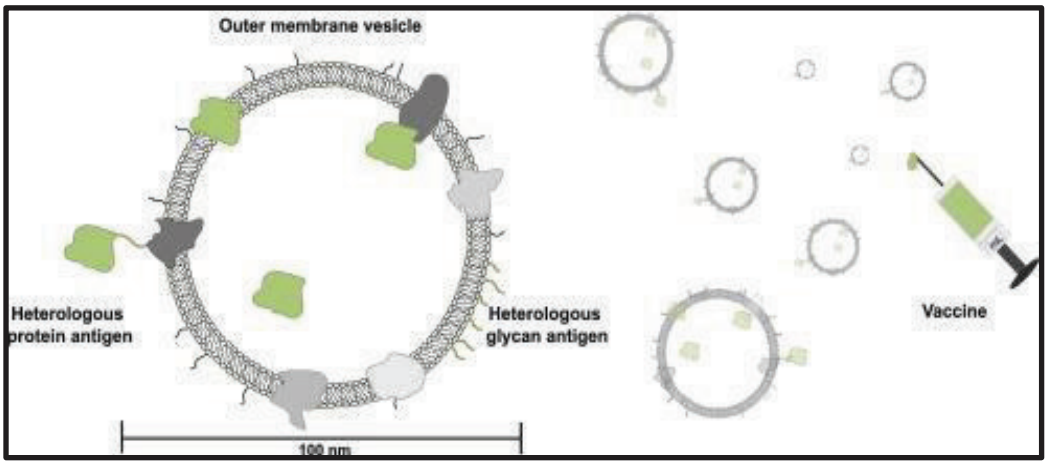

Fig 3 - Indicative picture of OMV Based Vaccine preparation

OMVs are natural immune adjuvants which can induce innate immunity by the activation of TLRs and NLRs and promote occurrence of adaptive immunity [11,12]. Along with that it has auxiliary characteristics as it can carry large number of antigens which are similar to that of bacterial cell surface hence pathogens are unable to mutate all the target antigens on OMVs, producing vaccines with lesser mutant forms. The non-replicative character of OMVs makes

them suitable candidate for antigen transport to the host cells [13]. OMVs may enters host cells by macropinocytosis, endocytosis, clathrin, caveolin or dynamin mediated entry.

Recent studies with mice have shown promising results for the use of OMVs to provide protection against infections caused by *N. meningitidis*, *Salmonella enterica* serovar Typhimurium, *H. pylori* and *Vibrio cholerae*.

On the process of developing vaccine, OMVs of group B meningococci suspended in saline and administered intranasally as drops or spray was found to be immunogenic in mice and humans even without the use of mucosal adjuvants [14].Similarly mice intranasally immunized with OMVs of *Vibrio cholerae* resulted in long-lasting immune response and provided protection to neonatals from the bacterial colonization in intestine[15].

A study report on efficacy and reactogenicity of OMV based cholera vaccine on rabbit in Removable intestinal tie-adult rabbit diarrhea (RITARD) model or Rabbit Model where intestines of rabbits were operated and treated with OMV based vaccine before exposing to different strain of cholera bacteria. It was observed that all rabbits treated with OMV based vaccine shows around 60-100 % effectiveness against all type of infection caused by different strain of cholera bacteria. Most significant part of these results shows that it has zero percentage death after treatment of infected rabbits injected by any type of cholera strain [16].

Similar type of results were observed in mouse model as well which are currently in trial phase and still not been used on human model. Scientists are very optimistic about it's result with the aim of eradication of death due to cholera.

Many theories based on action of OMV vaccines were put forward but none of them completely explains the whole pathway of action and research in this area is still going on. A study published in 2011, the most profoundly known theory works on inhibition of motility of *Vibrio cholerae* by IgG antibody as the primary mechanism of protection against the disease. Here, IgG binds to the O-antigen of the outer membrane sheath surrounding the *Vibrio cholerae* polar flagellum and imposes a crimping force, or alternatively it cross-links the sheath and flagellum to the cell body, as recently demonstrated for IgA. The flagellum no longer functions properly and *Vibrio cholerae* becomes immotile, incompatible to attack, hooks up with the epithelial cell and get passed out from the intestine. The bivalent structure of IgG acts as prerequisite for motility inhibition, much like its property for agglutination [17-18].

Although OMV based vaccines look promising it suffers from some major bottlenecks like high reactogenicity of PAMPs, low expression levels of relevant protective antigens, strain variation resulting in many subtypes of specific antigens thus lower coverage also existing biogenesis cannot fully explain the formation process of all bacterial vesicles, so further studies are needed.

Conclusion

Cholera, an acute diarrhoeal infection caused by different serogroups of *Vibrio cholerae* has existed with humans from a very early time, caused seven cholera epidemics in different parts of the world and still remains as a major threat for our society. Although its prevalence is controlled upto some level with hygiene and clean drinking water, its occasional infection and

epidemic outbreaks in different parts of the world has been frequently reported, for example recent spread in Haiti coast caused at least 10000 deaths in 2010. In developing countries like India with more specifically West Bengal which has recorded significant cholera cases, due to huge population should try to improve health, hygiene and supply of clean drinking water. It is still a huge project and needs many years of planning for its implementation. Vaccines could help us to achieve WHO task force target to eliminate cholera by 2030.

Today's commercially available vaccine which are WHO prequalified vaccines like Duckoral and shanchol are available in market but they are less effective, expensive along with high reactogenicity. So we need to develop highly effective with low adverse effect vaccine which could be affordable to within reach of common people. Outer membrane vesicle based vaccine of cholera made from OMV secreted from gram negative bacteria (here *Vibrio cholerae)* which is still under pre clinical trial could meet all these measures.

Mmvbax-sed vaccine was tested on retard model on rabbits has shown high efficacy and very high rate of productivity against *Vibrio cholerae* infection of same starion i.e homologous immunity as well as high rate of immunity against different strains of cholera i.e ; heterologous immunity. Although its shows least protectivity against SG24 and SG06 as its encapsulated nature of O antigen which make it unavailable from detection from antibodies induced by reference N16961 strain OMV based vaccines but it protects from death and still would be effective upto certain extent.

An extremely important pretext from a vaccination point of view, as different *Vibrio cholerae* serogroups and strains may be responsible for diarrhoeal diseases not only in different geographical locations, but also at the same site at a particular point of time. OMV based vaccines also shows lowest reactogenicity in HT29 cell than other present day vaccines. Similarly its provides immunity to mice and its suckling neonates by giving complete mucosal immunization against *Vibrio cholerae* for longer period shows and encourages for more research in this field. Although despite these advantages, only oral routes of immunization has been studied and other routes of immunization still need to be investigated in detail. Other challenges in OMV based vaccine development is that of balance of LPS at the time of OMV preparation for vaccines as high LPS may cause toxicity and different TLR response differently in human and mouse so we cannot completely presume same success rate in human trials.

Conflict of Interest: No conflict of interest was declared by the authors.

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Review Article

Gold Nanoparticles : A Magic Bullet To Treat Cancer

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Abstract: This review focuses on rearmost progresses in application of the gold nanoparticles (AuNPs) as a special agent to combat the cancer in human body. The properties of AuNPs made it valuable for the diagnosis and treatment of tumors. Due to their small size they are exclusively efficient in penetrating widely inside the tumor tissue. They also bind to different proteins and drugs and help transport them to their target site. Though the tumor imaging and radio sensitization have some limitation but they provide new strategies and innovative ideas for early diagnosis and precise radiation therapy. The gold bullets are gold nanocages when injected, selectively accumulate in tumors. When the tumors are later treated with laser light, the surrounding tissue is hardly warmed, but the nanocages convert light to heat, killing the malign cells. Gold nanoparticle research is still at it's infancy since many factors remain to be optimized before their implementation but in the near future, AuNPs will certainly play an important role in treatment of cancer**.**

Key Words : Gold nanoparticles, cancer treatment.

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Introduction

According to the World Health organization (WHO) in 2007, deaths from cancer was estimated for about 7.9 million. It is expected that the death rate will climb upto around 12 million by 2030. Therefore the research on cancer is consistently facing off the challenges in order to advance the most effective means of cancer diagnosis, monitoring and treatment. It would thus inevitably benefit mankind and save countless lives. Therapies that are currently employed for the treatment of cancer include surgery, chemotherapy and radiation therapy etc. Though these conventional methods have their own drawbacks e.g. surgical removal of tumours is restricted mainly to large, resectable and accessible tumours. Chemotherapeutic drugs target rapidly dividing cells and doesn't only kill cancer cells, but also destroy normal bone marrow cells and immune cells and this gives rise to severe "collateral damage" in patient's body. Radiation therapy involves the use of high energy radiation like X-rays and gamma rays to destroy tumour cells and inevitably causes deleterious effects to healthy tissues around it. In the modification of the above therapeutic methods a critical thrust towards improving cancer therapy to specifically target therapeutic agents to tumour cells while getting the healthy cells no or minimum harm. This is one of the emerging interest in nano technology research. Nano technology refers to the synthesis of materials having nano scale dimensions between 1 nm and 100 nm. The rapid expansion in nano material research increases the future prospect of novel diagnostic methods and treatment of diseases like cancer. This branch of nanotechnology in disease diagnosis, monitoring and treatment has been termed "nanomedicine" by the National Institutes of Health in the USA. Among the many nano materials being developed for medicinal therapeutic applications, the focus on gold nanoparticles (AuNPs) have caught the attention of researchers because of it's potential as tumour sensors, drug delivery agents and enhancers in plasmonic photothermal therapy for the eradication of cancers [1].

Synthesizing AuNPs

Synthesis of gold nanoparticles (AuNPs) is a very easy procedure. To perform the procedure we need–

- 20 ml of gold hydrogen tetrachloride solution
- 2 ml of sodium citrate solution
- 1 ml of sodium chloride solution
- Distilled water
- Magnetic stirrer and hot plate combination

Reaction :

$$\underset{\text{Gold ion}}{Au^{3+}} + \underset{\text{Citrate ion}}{C_6O_7H_5^{3-}} \rightarrow \underset{\text{Gold atom}}{Au^{0}}$$

This reaction results to gold nanoparticles as clusters of gold atoms and the colour of the solution is red (Fig. : 1). We can also increase the size and as a consequence change the colour of the gold nanoparticles and it's solution by adding NaCl solution to it.

Fig. : 1 Showing gold nanoparticle solutions of 20 nm (Red colour), >100 nm (Violet colour) and the bulk gold metal (Yellow gold colour)

Size dependency of AuNPs in cell internalization

There are different sizes of AuNPs such as 10 nm, 30 nm, 50 nm, 100 nm etc. The different sizes of the NPs act significantly in penetration in the tumor cell (Fig.2). It has been experimentally proved that AuNPs of 50 nm have highest penetration rate comparing than of other sizes (Fig.3) [2].

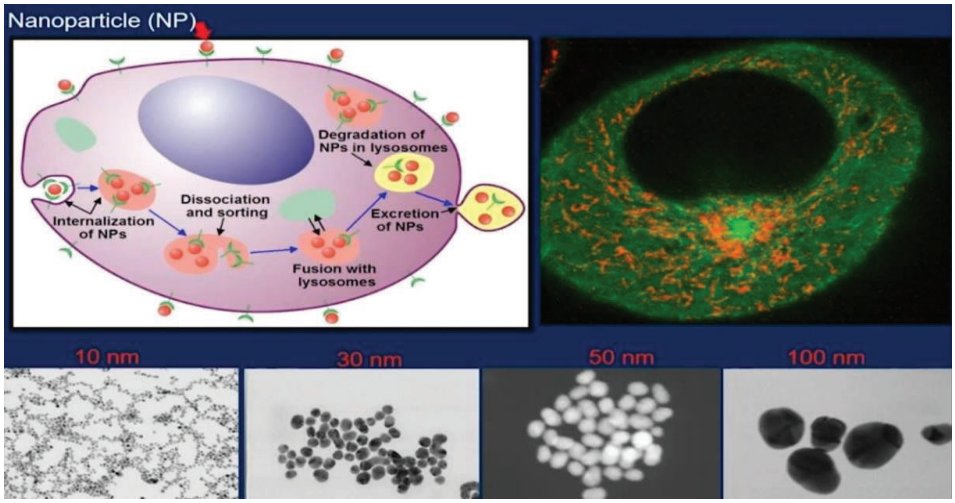


Fig.: 2 Showing nanoparticles internalizing inside the cell. The darker spot represents the nucleus, the red coloured areas represent gold nanoparticles and the green coloured areas represent the microtubules which are the highways of cell.

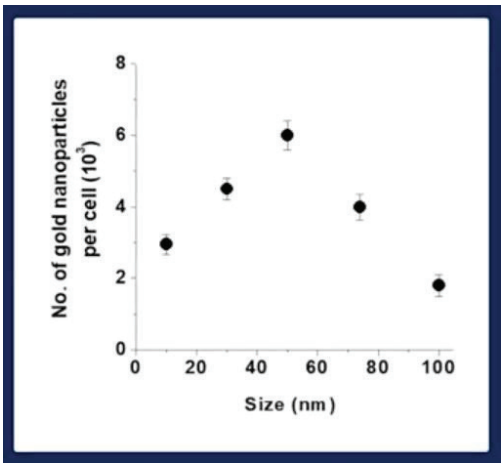
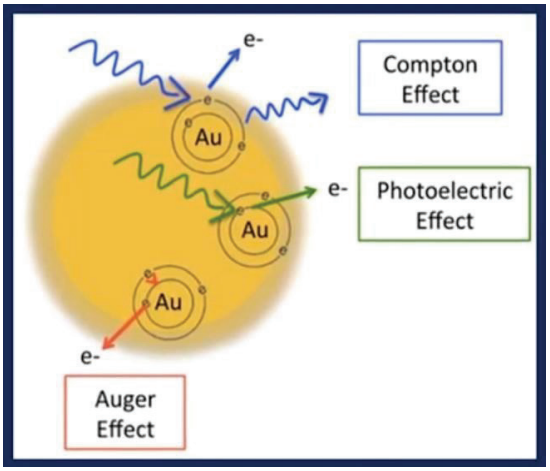


Fig.3. : Graph showing maximum number of AuNPs penetration in cell of 50 nm

Reasons of using gold nanoparticles

- As we are all aware that gold is a metal of high atomic number low reactivity. The high atomic number reveals that it has high amount of electrons so upon radiation therapy when the patients are treated with photons (as radiation), it kicks out so many electrons of the gold nanoparticles.
- Consequently there will be a shower of secondary electrons (Fig. 4A) and they interact with the water molecules present abundantly in our body and produce so many free radicals. These free radicals attack on the DNA (Fig. 4B). Therefore they cause death of the cell [3].



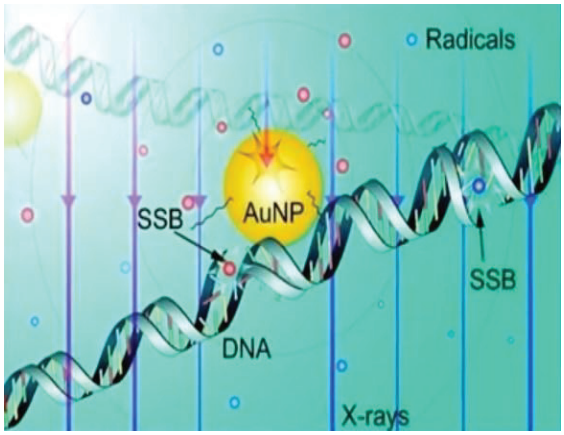


Fig A Fig B

Fig.4 A : Formation of secondary electrons from photoelectric and other effects

B : Formation of free radicals and attack on DNA leads to cell death

AuNPs and cytotoxicity :-

Bulk gold has been considered an inert metal for biomedicinal purposes and AuNPs have been thought to be same. In literature, AuNPs have been reported to lack the ability to induce adverse and acute toxicity and thus considered to be biocompatible entities for use in biomedical fields. However, recent studies have shown that there could be AuNP toxicity depending on it's size. The beneficial qualities of AuNPs include strong optical properties due to localized surface plasmon resonance (LSPR), control level surface chemistry which allows versatility in adding surface functional groups [4].

In vitro studies on cytotoxicity of AuNPs

Several studies have shown that AuNPs exert their cytotoxicity through induction of oxidative stress. For eg., 1.When 1.4 nm AuNPs are exposed to HeLa cervical carcinoma cells, they exhibited increased reactive oxygen species (ROS) production and oxidative stress, leading to protein and lipid oxidation, severely impaired mitochondrial function and eventually cell death. 2. On the other hand, when 20 nm AuNPs are exposed to MRC-5 fetal human lung fibroblast cells, it leads to concomitant down-regulation of cell cycle genes such as Cyclin B2 and B1 and DNA damage response genes. In spite of these results, the same researchers also demonstrated in a study that AuNP treatment led to up-regulation of antioxidant and expression of stress response gene and proteins.

In vivo studies on cytotoxicity of AuNPs

In a study, when blue mussel (*Mytitus edulis*) was exposed to AuNPs, it was observed to experience oxidative stress within 24 hrs., indicating the possible impact of AuNPs to aquatic animals and ecosystem. In another study, the real-time effects of AuNPs was experimented on zebrafish embryos. The results showed that random diffusion of AuNPs to various parts of the embryo was relatively non toxic in nature and AuNPs could be used for in vivo imaging applications for embryonic studies. Another study regarding intravenous administration on a rat model shows, I. Upon iv of 10 nm AuNPs the distribution was found to be widespread, permeating the blood and organs of the cardio-respiratory system, immune system (such as spleen and thymus) and reproductive system, liver, kidney and brain. II. Larger AuNPs (50,100 and 250 nm) where localized only to the blood, liver and spleen. The results imply that smaller size AuNPs are more accessible to various tissues in the body and therefore have the ability to cause wide-spread harm, if any [5].

On the contrary the same group of researchers also demonstrated that administration of 4 nm or 100 nm PEG-coated AuNPs in mice induced up-regulation of common genes associated with apoptosis, cell cycle, inflammation and metabolic process in liver tissues. The major challenge in the field of in vivo cytotoxicity of AuNPs is the plausibility of translating observed cellular and immunological toxicity in animal models to humans, since there are distinct intra and inter species variations.

Applications of AuNPs in cancer management

AuNPs as sensors for proving and imaging tumour cells :

For leveling applications AuNPs are good because of their ability to interact strongly with visible lights. Upon exposure to light, pre electrons in gold atoms are excited to a state of collective oscillation known as surface plasmon resonance (SPR), conferring gold the ability to absorb and scater visible light and they enable visualization of the region under study. AuNPs then be detected by any of the following ways : phase contrast optical microscopy, dark field microscopy, photothermal imaging and photoacoustic imaging. The most crucial step of cancer therapy involves early diagnosis. Through the conjugation of antibodies specific for antigen overexpressed on tumor cells, AuNPs can be detected to tumor cells and pin pointing their precise location in the body. Surface-enhanced raman spectroscopy (SERS) imaging of tumor bio markers which are over expressed in MCF7 breast cancer cells [6].

(Raman scattering is a phenomenon that results from the inelastic collision of photons with molecules where energy, which is either lost or gained, translates to a change in the frequency of the scattered photons. This unique shift of frequency depends on the characteristic energy of molecular vibrations constituting the signal, hence a Raman spectrum consisting of different signals from molecular vibrations forms a "vibrational fingerprint" of a molecule.)

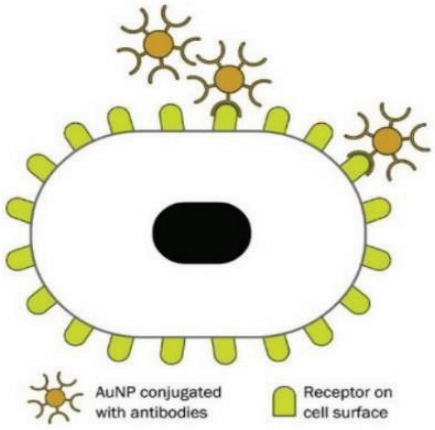


Fig.5 : Schematic diagram showing the localization of antibody conjugated gold to receptors present on the plasma membrane of cells

Current studies have demonstrated the potential use of AuNPs for in vivo targeted imaging of cancer using SERS. This shows that successful optical imaging performed in mice cannot be directly scaled for in vivo imaging of human subjects because of limited optical signal tissue penetration ability. Technological improvements by using screen-printed carbon electrode (SPCE) coupled with a NP-based electrocatalytic method led to detect and quantify in situ tumor cell proliferation via the reaction of cell surface protein with specific antibodies conjugated through AuNPs (Fig.5) [7].

Experiment:

a) Quantification of DNA double-strand breaks (DSBs) involved assaying a minimum of 50 nuclei per sample.

b) Image intensity-based thresholding and segmentation used for DSB quantification.

c) Two proteins, c-H2AX and 53BP1, targeted for detection at DSB sites using wide-field imaging.

d) Fig. 6 display images of nuclei from reference cells (without nanoparticles) and cells with nanoparticles.

e) The experiment shows with NPs the γH2AX foci per nucleus i.e. number of DNA double-strand breaks in single cells is maximum [8].

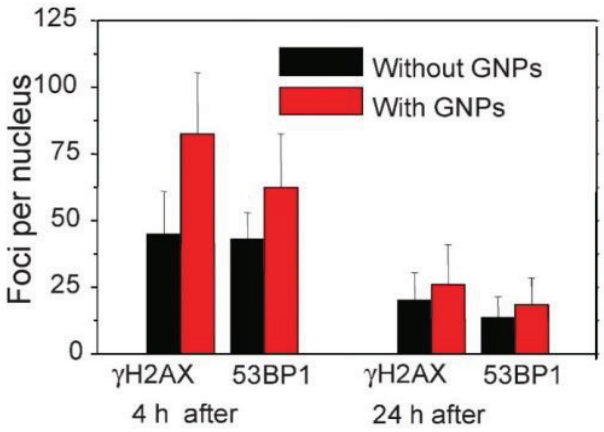


Fig.6 : The graph shows quantification of c-H2AX and 53BP1 radiation induced foci after 4 Gy of 220 kVp X rays[cells pretreated with gold nanoparticles (red) and with no gold nanoparticle pretreatment (black)]

A study on mice bearing subcutaneous EMT-6 mammary carcinomas showed that not only were AuNPs (1.9 nm in diameter) non-toxic in nature and cleared from the body via the kidneys, they possessed the ability to enhance the effect of X-ray therapy leading to a remarkable survival rate of 86% as opposed to 20% with X-rays alone and 0% with AuNPs alone. According to some researchers, the effectiveness of AuNPs as radiosensitizers seems to be strongly reliant on the nature of their coating [9-10].

AuNPs as antiangiogenic agents:

AuNPs have been reported to inhibit angiogenesis by preventing the downstream signaling effects of these mitogens on angiogenesis in cancer cell (Fig.7). Generally normal epithelial and endothelial cell linings are the main obstacles. But in tumor cells their own endothelial lining are not structurally as perfect as the normal ones. So AuNPs can easily leak in their endothelial tissues and help the targeted drug carriers to act specifically on the tumor tissues without affecting it's surrounding healthy tissues [11].

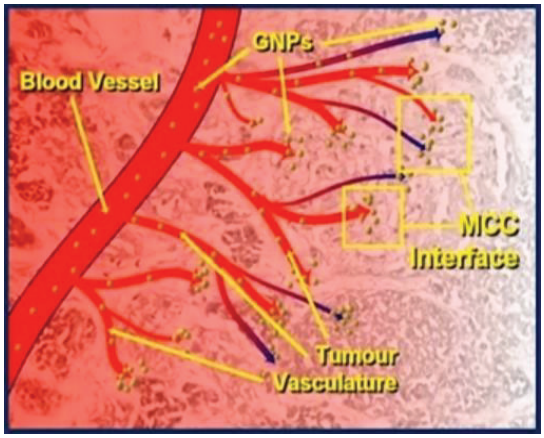


Fig.7: Accumulation of AuNPs in cancer endothelium tissues

AuNPs as drug delivery agents targeted to cancer cells:

The interesting application of the AuNPs in their use as vehicles for delivery of drug molecules into cells. Various factors need to be considered in designing and effective drug delivery system. The properties of AuNPs such as their size charge and surface chemistry affect the uptake of AuNPs into cells. In order to ensure the specific killing of cancer cells while sparing healthy cells AuNPs were conjugated with appropriate surface ligands which directed them only to tumor cells (Fig. 8A & B). The first involved conjugation of AuNPs to PEG, and the second involved conjugation of AuNPs with specific antibodies which bind unique biomarkers expressed on tumor cell [12].

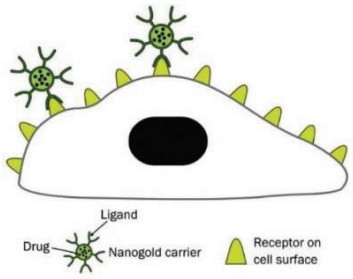


Fig A

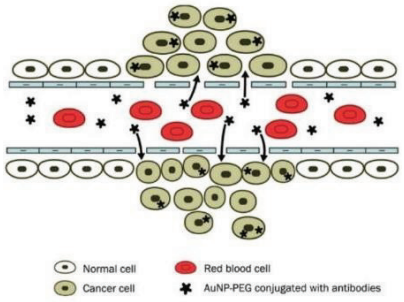


Fig B

Fig 8A: Schematic diagram showing AuNP carrier conjugated with anticancer drugs and ligands which are recognized by receptors on the surface of tumor cells.

Fig 8B**:** Schematic diagram showing accumulation of ligand targeted gold nanoparticles conjugated with anticancer drugs in cancer cells mediated via extravasation of the gold nanocarriers through gaps in the endothelial cells ("leaky tumor vasculature").

Repurposing of anti-cancer drug ; Docetaxel (DTX) :

Docetaxel is a famous drug for treatment of various kinds of cancers. A new approach has been taken to incorporate DTX with AuNPs led to significant results in radiation therapy (Fig.9).

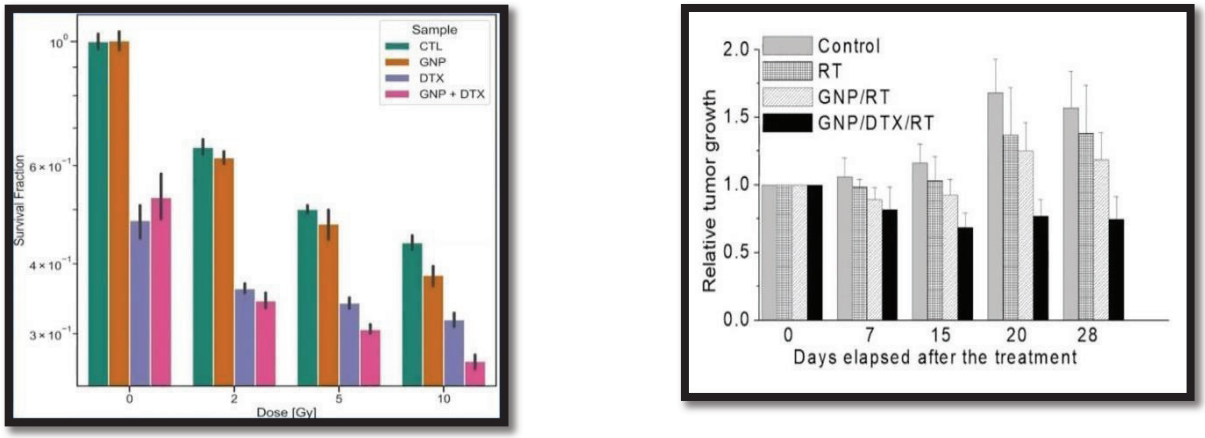


Fig.9: The graphs showing therapeutic benefits of triple combination of DTX/RT/GNPs in artificial 3d tissue model

The triple combination not only just worked in vitro model but also when applied on rat model it shows significant control tumor growth.

Gold nanoparticles can be also associated with different nano particle platforms as a drug carrier to the target sites of cancer cells. One of the nanoparticle platforms is lipid based nanoparticles. Lipid can form a peculiar structure called liposome which contains a aqueous medium in it's centre. To protect from macrophagic activities a layer of PEG is covered outside it. Gold nanoparticles and the desiring drug is inside the aqueous medium. This process needs high-end technology. In association with gold nanoparticles the LNPs surprisingly show high accumulation rate inside tumor cells [13].

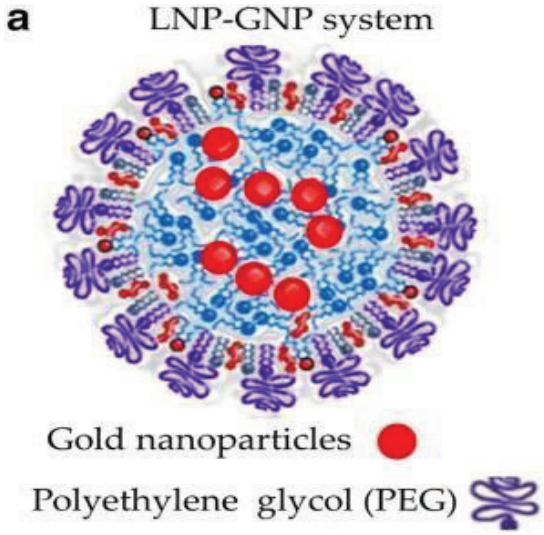


Fig. 10 : In association with gold nanoparticles the LNPs surprisingly show high accumulation rate inside tumor cells

AuNP Accumulation in CAF

When we discuss about tumor we are not just talking about only the tumor tissues rather a micro environment (Fig. 11) consisting of blood and lymphatic vessels, normal healthy cells, normal fibroblast cells etc. In the tumor cells some of the normal fibroblast cells are converted into Cancer Associated Fibroblast (CAF). In some mechanisms the CAFs induce the growth of the tumor cells [14].

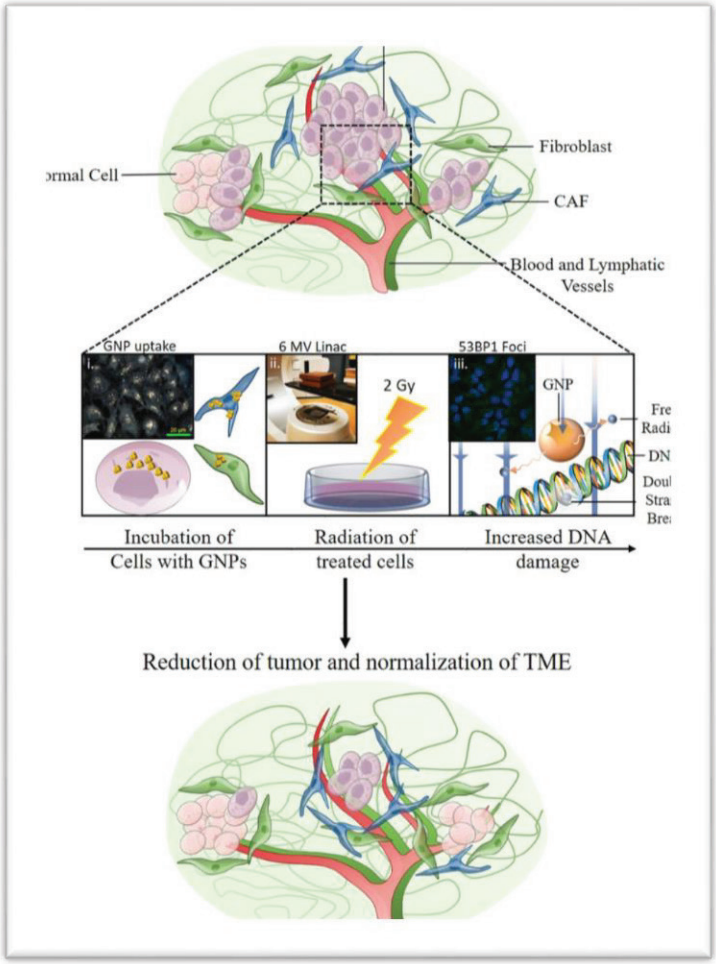


Fig. 11 : Tumour microenvironment

CAFs are introduced, a largely pro-tumourigenic influence is now exerted on the tumour microenvironment, leading to growth and eventual metastasis. (i) Cells uptake GNPs at differing rates, which is directly related to the efficacy of the treatment. (ii) Cells are irradiated with a 2 Gy dose using a 6 MV linac. (iii) GNPs have been shown to have a radiosensitization effect on cancer cells, through improved formation of free radicals. Upon treatment with the dual combination of GNPs and radiation, the TME (Tumour microenvironment) is more normalized and there is a reduction in tumour growth as well as invasive and migratory behaviour. It has been seen that the gold nanoparticles entry in among normal fibroblast, HeLa and CAF the most penetration rate can be seen in CAF so that it can be easily treated by radiation therapy most efficacy (Fig.12).

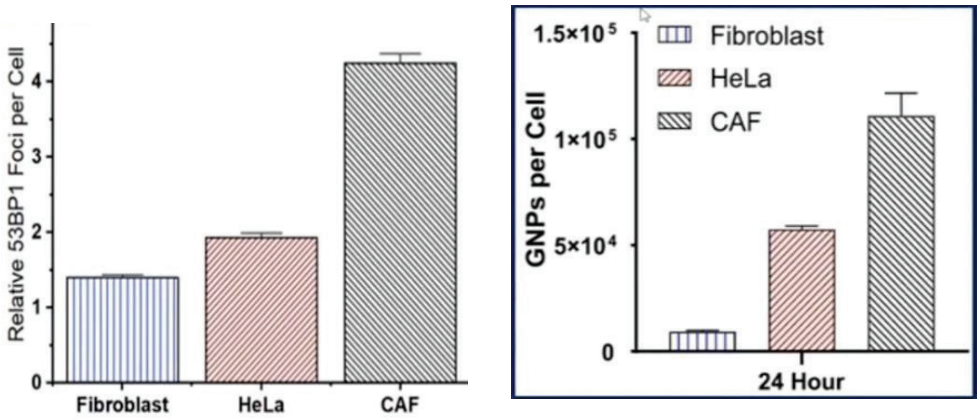


Fig.12 : Both graphs showing maximum AuNPs accumulation in CAF

CONCLUSION

a) The properties of AuNPs made it valuable for the diagnosis and treatment of tumors.

b) Due to their small size they are exclusively efficient in penetrating widely inside the tumor tissue.

c) They also bind to different proteins and drugs and help to transport them to their target site.

d) Though the tumor imaging and radiosensitization have some limitation but they provide new strategies and innovative ideas for early diagnosis and precise radiation therapy.

e) Gold nanoparticle research is still at it's infancy since many factors remained to be optimized before their implementation but in the near future, AuNPs will certainly play an important role in treatment of cancer.

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