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Analysis of Industrial Wastewater Treatment Plant Trends and Innovations for the Future

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Abstract: *The crucial nexus of environmental sustainability and economic productivity is industrial wastewater treatment facilities, or IWWTPs. In contrast to municipal sources, industrial effluent exhibits significant heterogeneity, with highly fluctuating levels of suspended particles, recalcitrant organic compounds, hazardous heavy metals, and emerging pollutants. Because of this complexity, customized, multi-stage treatment trains are required, which frequently combine advanced biological, chemical, and physical techniques (such as membrane bioreactors, electrochemical oxidation, and anaerobic digestion).This examination looks at the current imperative that drives IWWTP design: creating a Circular Economy framework rather than just complying with regulations. Today's IWWTP is seen as a vital facility for resource recovery, including the recovery of process water, the collection of valuable byproducts, and the production of bioenergy (biogas), rather than as a cost center devoted exclusively to pollutant attenuation. In order to accomplish this paradigm shift, innovative, scalable technology must be strategically deployed, and strict, real-time monitoring must be maintained to guarantee effluent quality and operational effectiveness. Global industrial expansion's feasibility is intimately correlated with the effective, long-term management that these specialized treatment environments provide.*

Keywords*:* Chemical Treatment, Sensor, Industrial wastewater, IWWTPs, IoT

I. INTRODUCTION

Before returning contaminated water to the environment, wastewater treatment facilities use physical, biological, and chemical procedures to purify it from residences, workplaces, and industries. Three basic steps are usually involved in the process: primary treatment, which removes big solids; secondary treatment, which uses microbes to break down organic waste; and tertiary treatment, which uses more sophisticated techniques including filtering and disinfection to further purify the water [1-40].

The operation of wastewater treatment facilities

- Pre-treatment: After entering the plant, wastewater is passed through screens to get rid of big material including grit, twigs, and rags.
- Primary treatment: After that, the water is transferred to sizable settling tanks, where it remains for a while. This removes heavy solids by allowing them to sink to the bottom and lighter materials, like grease, to float to the top.
- Secondary treatment: After passing through aeration tanks, the wastewater is combined with microorganisms and air. The organic contaminants in the water are eaten by these microbes. The microorganisms, now known as activated sludge, are then allowed to settle out of the mixture in a second settling tank. To treat the subsequent wastewater batch, some of this sludge is recycled back into the aeration tank.

- Tertiary treatment: This advanced step purifies the water even more. Filtration can be used to eliminate any leftover suspended particulates, and UV light or chemical disinfection can be used to eradicate dangerous germs and viruses. In order to keep receiving waters from becoming eutrophic, certain sophisticated plants may additionally extract nutrients like phosphate and nitrogen.
- Discharge: The clean water is discharged into a lake, river, or ocean following the phases of treatment.

The reasons behind their significance

- Protection of the environment: They stop natural water bodies from becoming contaminated by contaminated water.
- Public health: By eliminating dangerous materials and bacteria, they render water environmentally safe and may even result in its reclamation for future purposes.
- Resource recovery: Some contemporary plants are built to generate clean water for future use or even to recover resources like electricity from the treatment process.

II. INDUSTRIAL WASTEWATER TREATMENT PLANT

Facilities known as industrial wastewater treatment plants (IWWTPs) use a mix of physical, chemical, and biological techniques to remove contaminants such as chemicals, heavy metals, and oils from water that has been contaminated by industrial activities. Following treatment, the water can be safely released into the environment or used again, assisting businesses in meeting legal requirements, safeguarding public health, and reducing their negative environmental effects. The example of IWWTPs is shown in Figure 1[42-100].

Steps and procedures

- Physical processes: These employ physical separation techniques to eliminate contaminants. Filtration is the process of separating particles from water by passing it through filters.
- Flotation: Dissolved Air Flotation (DAF) systems, which work well for turbid and oily wastewater, use air bubbles to cause pollutants to float to the top for removal.
- Separation: Separate phase oil is extracted from wastewater using oil-water separators.
- Chemical reactions: These cleanse water using chemicals. In order to facilitate the removal of small particles, chemicals are added to cause coagulation and flocculation. Neutralization is the process of bringing the water's pH down to a neutral level.
- Oxidation: The breakdown of complex substances by the use of oxidizing chemicals.

The biological processes:

These decompose organic materials using microbes.

- This is especially helpful for dissolving oils, greases, and biodegradable compounds.
- Technologies such as the AVR™-AF system are made to effectively treat wastewater from the dairy and food sectors biologically.

Industrial WWTP types Wastewater from a variety of industries is treated by general industrial WWTPs.

- Specialized WWTPs: Establishments designed to handle the particular wastewater characteristics of particular industries, such as petrochemical, food and dairy, or chemical factories.
- Pretreatment facilities: These plants, which are housed inside factories, clean wastewater before it is transferred to a municipal sewer system for additional processing.

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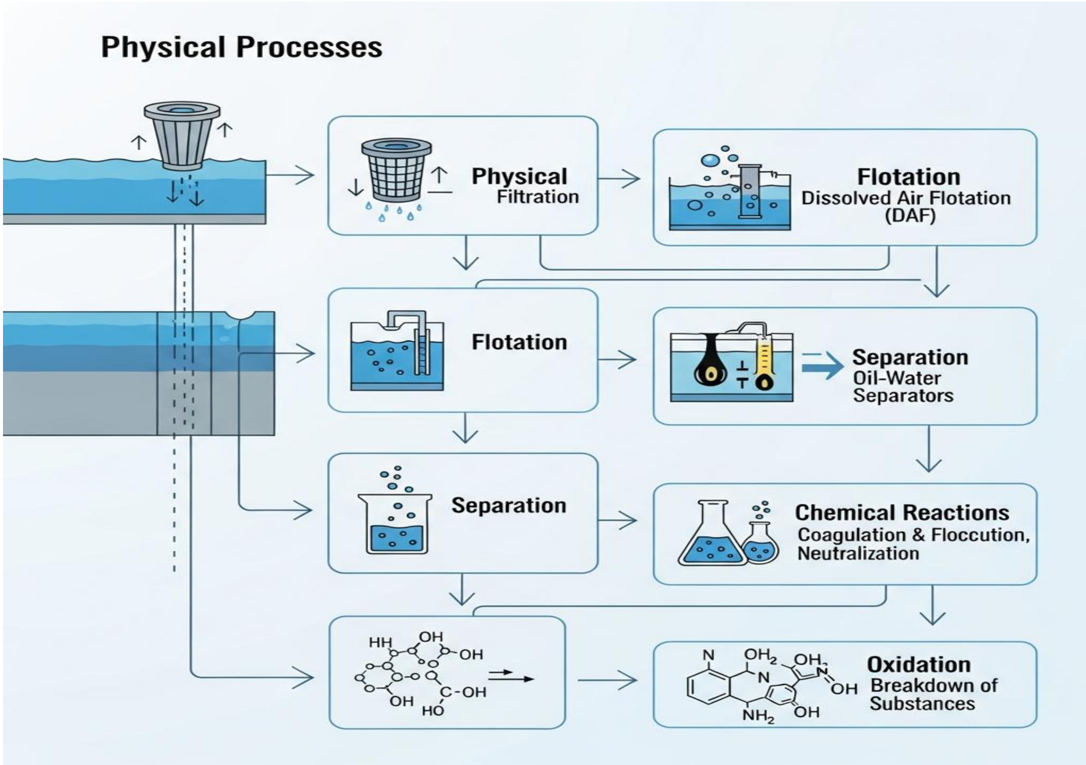

Figure 1: Steps of IWWTPs

III. HOW IOT AND SENSORS ARE REWRITING THE RULES OF INDUSTRIAL WASTEWATER TREATMENT

For a long time, industrial wastewater treatment plants (IWWTPs) have had two main goals: to maintain regulatory compliance and control exorbitant operating expenses. In industries ranging from food and beverage to manufacturing and chemicals, the WWTP is frequently seen as an essential, high-overhead cost center.

But this story is radically shifting due to the quick adoption of advanced sensor technologies and the Industrial Internet of Things (IIoT). These technologies are ushering in the era of Water 4.0, which will make industrial water management not just compliant but also optimized, efficient, and predictive by converting decades-old, reactive processes into precision-engineered, data-driven systems [101-150].

Industrial effluent is infamously volatile, in contrast to municipal wastewater. Depending on changes in source materials, cleaning cycles, and production schedules, its composition might alter significantly. Conventional therapy mostly depends on routine laboratory analysis and manual sampling, which takes a long time and causes a big delay between a process disruption and remedial action.

This delay is expensive:

- Chemical Waste: To account for uncertainty, operators frequently overuse chemicals (such as pH buffers or flocculants).
- Overuse of Energy: One of the biggest energy users in an IWWTP is aeration, which is required to feed beneficial microbes. Compressors operate inefficiently in the absence of exact data.
- Compliance Risk: Biological processes may be killed by an unexpected burst of hazardous or high-strength waste, resulting in environmental violations and hefty fines.

Part 1: The Sensor Revolution: From Streaming to Samples

Advanced in-situ sensors, which serve as the digital WWTP's eyes and ears, are the first step in the fundamental revolution. By transforming physical and chemical characteristics into continuous data streams, these instruments measure important parameters in real time.

Important Sensing Uses:

1. Accurate Aeration Management: Often, dissolved oxygen (DO) sensors have the biggest influence. Maintaining particular DO levels is necessary for biological treatment. Conventional techniques frequently overaerate, wasting a great deal of electricity. IoT controllers and contemporary optical DO sensors enable blowers to modify frequency and speed in response to the precise requirements of the microbial community, resulting in 20% to 40% energy savings.
2. Monitoring of Contaminants in Real Time: Although it takes days to test for metrics like Biological Oxygen Demand (BOD) and Chemical Oxygen Demand (COD) in a lab, online sensors, such as UV-Vis spectrophotometers and sophisticated respirometers, can assess organic load almost instantly. This enables quick mixing and dosing changes or the direct transfer of high-strength effluent to equalization tanks before the downstream process is overloaded.
3. Monitoring of Flow, Level, and Pressure: Simple yet essential, ultrasonic level sensors and smart flow meters offer constant insight into the hydraulic behavior of the plant. In order to avoid expensive surges or dry-running failures, this data is essential for calibration, leak detection, and making sure pumps and valves are operating within ideal operational curves.
4. Oxidation-Reduction Potential (ORP) and pH : Processes used in industrial neutralization are very prone to variations. In addition to reducing reagent consumption and guaranteeing that the effluent satisfies the neutral range needed for disposal or additional biological treatment, IoT-enabled pH and ORP monitors offer the feedback required for automated, precise chemical dosing.

Section 2: Data Synthesis and Intelligence at the Core of the Internet of Things

Data collection is just the beginning. The IoT platform itself, the network architecture that collects, processes, and converts continuous sensor data into useful intelligence, is where the real power is.

1. Cloud computing and edge processing:

In order to handle instant alerts (such as "pH just dropped by 2 points—shut the valve!"), data from localized sensors is frequently handled at the "edge" (on-site controllers), guaranteeing quick reaction times. At the same time, this data is safely sent to an IoT platform that is hosted in the cloud.

Strong Machine Learning (ML) algorithms on the cloud compare real-time inputs with enormous historical datasets. With this synthesis, the WWTP transitions from using retrospective reports to managing it to using predictive analytics.

2. Asset Integrity and Predictive Maintenance:

IoT sensors track the temperature, vibration, and power usage of vital equipment rather of waiting for a pump to break (reactive maintenance). A work order is automatically initiated by anomalies that indicate an imminent bearing failure or obstruction. This significantly lowers unplanned downtime, which can have disastrous consequences for compliance.

3. Process Optimization and Automatic Dosing:

The intricate connections between temperature, flow rate, incoming pollutant load, and the ideal dosage of a polymer or disinfectant can be learned using ML models. The system accurately determines the minimal effective dose rather than operators speculating, which results in significant chemical cost savings and more steady effluent quality.

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Section 3: The Measurable Benefits: Sustainability and Efficiency

For industrial operators, integrating sensors and the Internet of Things (IoT) yields a significant return on investment (ROI), which significantly boosts profitability, as Table 1 illustrates:

Table 1: IoT and sensors Benefits

Benefits	Description	Effect
Operational Efficiency	Optimal chemical dosing combined with precise aeration and mixing control.	20–40% less electricity is used, and chemical expenditures are reduced by 10–25%.
Regulatory Assurance	Discharge violations are avoided with real-time alarms and continuous, verified data logs.	Reduced possibility of penalties and improved publicity.
Predictive Reliability	Unexpected failures are avoided by keeping an eye on the condition of assets (pumps, mixers, UV systems).	Optimized maintenance scheduling and decreased unplanned downtime.
Remote Management	Optimized maintenance scheduling and decreased unplanned downtime.Mobile dashboards allow engineers and operators to keep an eye on plant performance.	Simplified personnel management, which is particularly helpful for industrial operations involving several sites.
Sustainable Practices	Using resources (energy, water, and chemicals) efficiently reduces the environmental impact overall.	Lowers carbon emissions and promotes corporate sustainability goals.

The intelligent WWTP of today is very predictive and tuned. The plant of the future is rapidly approaching complete autonomy.

- Industrial WWTPs will be able to manage complicated, unanticipated occurrences without the need for human intervention when more sensor data is integrated with strong AI systems.

In addition to identifying an abnormality, the system will simulate possible consequences, self-diagnose the cause (for example, "The upstream process released a high-pH cleaning solution"), and automatically carry out a multi-step mitigation approach (such as raising acid dosing, diverting flow, and alerting maintenance).

IoT adoption is becoming a strategic need for business executives rather than a luxury. It turns the IWWTP from a reactive, weak cost center into a data-driven, robust asset that is necessary to uphold operational stability, guarantee compliance, and provide improved corporate sustainability. The arrival of the digital flood promises smarter business and cleaner water [151-199].

IV. CHEMICAL PROCESS INVOLVED IN IWWTPS

A more subdued but no less important ballet is taking place beneath the cacophony of industrial behemoths, where the rhythm of manufacturing churns forth a bounty of things. The industrial wastewater treatment facility is an invisible battleground where purity is the goal and chemistry is the weapon. It is the silent, never-ending alchemy of this place. Here, a disorganized mixture of organic substances, heavy metals, manufacturing waste, and stubborn contaminants is meticulously converted, molecule by molecule, into water that is suitable for reintroduction into the natural world.

Wastewater from industry is not your typical effluent. In contrast to municipal sewage, its makeup is as varied and intricate as the industries from which it comes: mining leachates, petrochemical hydrocarbons, textile colors,

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pharmaceutical residues, plating solutions, and food processing waste. Each poses a different difficulty, a molecular riddle requiring specialized chemical fixes. This is the point at which chemical engineering truly excels.

Neutralization is frequently the first step in the process. Highly acidic or alkaline wastewater, which is destructive to infrastructure and deadly to aquatic life, is regularly released by industrial processes. Here, the exact architects are introduced: bases like calcium hydroxide or caustic soda (sodium hydroxide) or acids like sulfuric acid. Their goal is to return the pH to a neutral, life-sustaining range, usually between 6.0 and 9.0, so that the water is ready for more advanced treatments down the road. It's the essential initial step, a careful balancing act between hydroxyl ions and protons.

Next, the graceful two-step dance of coagulation and flocculation is used for suspended solids, colloids, and finely dispersed particles that defiantly refuse to settle. Imagine small, charged particles repelling one another in a minuscule mosh pit. Coagulants are added, frequently metal salts such as ferric chloride or aluminum sulfate (alum). The particles lose their distinct identities and start to cluster together as a result of these chemicals neutralizing their surface charges. Coagulation is what this is. The flocculants, which are long-chain organic polymers, are then introduced. The neutralized, newly formed micro-flocs are entangled by these polymers, which link them into larger, heavier aggregates known as "flocs," which are now substantial enough to settle away under gravity in clarifiers, leaving behind clearer water. This process is similar to tiny spiderwebs.

The plant uses the brute-force elegance of Advanced Oxidation Processes (AOPs) to remove the more pernicious dissolved organic contaminants, such as colors, insecticides, and medications, that avoid physical separation. The molecular ninjas are useful in this situation. Highly reactive hydroxyl radicals (•OH) are released by chemicals such as ozone (O3) and hydrogen peroxide (H2O2), which are frequently coupled with UV radiation or catalysts (such as iron in the Fenton reaction). These ephemeral, strong species are oxidizers of indiscriminate strength. They tear complex organic molecules' chemical bonds apart, converting them into simpler, frequently biodegradable chemicals or even totally mineralizing them into water and carbon dioxide. The best way to eradicate obstinate infection is with AOPs.

Certain pollutants require targeted removal in addition to destruction. Ion exchange and adsorption come next. Activated carbon mechanically traps organic micropollutants, colors, and scents onto its large surface area thanks to its labyrinthine porous structure. Ion exchange resins are used for heavy metals that have particular ionic charges, such as lead, mercury, or cadmium. By "snapping up" the poisonous species and leaving the water clearer, these ingenious polymers selectively replace the troublesome metal ions with less hazardous ones. It's a targeted attack, a molecular swap that guarantees the isolation of particular pollutants.

Lastly, despite thorough chemical cleaning, the water can require one last defense against invisible biological dangers. Disinfection guarantees that all remaining germs are eliminated and frequently uses chlorine (in different forms, such as sodium hypochlorite), ozone, or chlorine dioxide. Before the treated water is released or used again, these potent oxidizers break down the genetic material and cell membranes of microorganisms, making bacteria and viruses innocuous.

Industrial wastewater treatment plants' chemical processes are more than just a sequence of events; they are an example of how inventive people can be in protecting our most valuable resource. They are a dynamic, ever-evolving field that is always looking for solutions to clean up the industrial footprint that are less energy-intensive, sustainable, and efficient. The water that flows out is a testimonial to the purity that is secured within thanks to a symphony of chemistry that involves acids, bases, polymers, oxidizers, and adsorbents.

V. CHEMICAL PROCESS INVOLVED IN DISINFECTION OF IWWTPs

The hidden infrastructure devoted to cleanup, rather than lofty policy declarations, frequently serves as a better indicator of a society's actual environmental commitment. The advanced procedures used to treat industrial wastewater are the clearest example of this.

Industrial effluent is a dynamic, complicated concoction that includes heavy metals, specialty colors, high organic loads, and, most importantly, a dense population of hardy microbes. This is in contrast to municipal sewage, which is comparatively predictable. Before reintroducing water into the natural cycle, disinfection—a chemical intervention—is

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the last and most important step in controlling this discharge. Here, the Unseen Alchemist uses powerful chemistry to destroy viruses, which are biological warfare agents, protecting the environment and public health.

Disinfection is usually the last polishing stage in the treatment of industrial wastewater, after basic treatment (solids removal) and secondary treatment (biological elimination of biochemical oxygen demand, BOD). The performance of these earlier steps is crucial to the effectiveness of disinfection since excessive concentrations of organic matter and suspended solids (TSS) can either "shield" bacteria or react with disinfectants, reducing their effectiveness.

The procedure depends on interfering with the pathogens' (bacteria, viruses, protozoa, and parasitic worms) fundamental biological processes. Advanced oxidation, the chemical process that steals electrons from microbial cell structures and ultimately causes cellular failure and death, is the main mechanism by which this disruption is accomplished.

The industrial arsenal uses a rotating pool of potent chemical agents, each chosen according to the intended environmental residue, cost restrictions, and the particular effluent composition.

1. Chlorination: The Classic Workhorse

Chlorine, typically dosed as liquid chlorine gas Cl2 or sodium hypochlorite NaOCl, remains the most widespread and cost-effective disinfectant. When chlorine contacts water, it creates two primary germicidal agents:

$$Cl2+H2O \rightleftharpoons HOCl+HCl$$

The chemical star is hypochlorous acid, or HOCl. Its ability to readily penetrate microbial cell walls makes it electroneutral and extremely effective. Once inside, it quickly kills cells by oxidizing important respiratory enzymes.

Chlorine has a major disadvantage, especially in complex industrial streams, despite its strength and ability to leave a lasting residual, which means the water remains disinfected for a while after treatment:

- Disinfection Byproducts (DBPs): Trihalomethanes (THMs) and Haloacetic Acids (HAAs) are two carcinogenic chemicals that are produced when chlorine combines with residual dissolved organic debris, which is frequently found in pharmaceutical or industry wastewater.
- Chlorination frequently necessitates a subsequent step, dechlorination, which is accomplished by adding reducing agents like sodium bisulfite or sulfur dioxide, which neutralize the excess chlorine before discharge because it is environmentally unacceptable to discharge water that contains both DBPs and residual active chlorine.

2. Ozonation: The Ephemeral Powerhouse

Three oxygen atoms bound together to form an unstable, extremely reactive gas make up ozone O3, an allotrope of oxygen. Ozonation is frequently used when residual medicines or high color concentrations are present in industrial effluent, or when it is imperative to prevent the development of DBP.

Compared to chlorine, ozone is a much more potent oxidant. It kills infections by vigorously oxidizing the cell membrane from the outside; it doesn't just rely on penetration.

Ozone's chemical benefits include:

- Broad Spectrum: Ozone works well against bacteria like Cryptosporidium that are resistant to chlorine.
- Speed: Ozone requires a far shorter disinfection contact time than chlorine (typically minutes versus 30-60 minutes).
- Clean Decomposition: Ozone's decomposition product is its main benefit. After completing its task, the O3 molecule quickly transforms back into stable, innocuous oxygen O2, producing no hazardous DBPs and leaving no toxic chemical residue.

Since ozone gas must be produced on-site using electrical discharge through dry air or pure oxygen, the main drawbacks of ozonation are its high capital and energy expenses.

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3. Peracetic Acid (PAA): The Modern Green Alternative

Because of its advantageous environmental profile, peracetic acid, $CH3CO3H$ often known as PAA, has become increasingly popular, particularly in the food and beverage industry and sophisticated industrial sectors. PAA is a liquid oxidant that works by causing highly damaging free radicals to develop, which damages the cell membrane. It works well in a variety of pH and temperature ranges.

The Advantage of PAA:

- Effective Against Biofilms: PAA has a reputation for penetrating and destroying enduring biological growths that are frequently found in industrial pipe systems.
- Minimal Environmental Impact: Similar to ozone, PAA breaks down into innocuous substances, mostly water, oxygen, and acetic acid (vinegar). The expensive and intricate dechlorination systems that chlorine requires are no longer necessary thanks to this breakdown.
- Less Affected by Industrial TSS: Facilities with greater effluent quality variability can nevertheless maintain disinfection standards since PAA's reactivity is less inhibited by leftover organic matter than chlorine.
- Because PAA is caustic, handling it safely is a challenge, as is the fact that it leaves no lasting residue. Despite being better for the environment, the effluent does not give the plant the long-term disinfection that chlorine does.

Due to the extremely varied influent composition, disinfecting industrial wastewater is far more difficult than municipal treatment. Chemical interference occurs when disinfectants are scavenged by dyes, phenols, heavy metals, and complex synthetic chemicals originating from production processes. This necessitates minute-by-minute massive dose adjustments.

- Pathogen Resistance: Microorganisms that have grown more tolerant or resistant to common disinfectants can be released by specific industrial sectors (such as concentrated animal feeding operations and pharmaceutical production). The use of Advanced Oxidation Processes (AOPs), which combine disinfectants (like O3 or H2O2) with potent catalysts like UV light to create exceptionally high concentrations of hydroxyl radicals for rapid sterilization, is frequently required when unexpected spikes in contaminant concentration (also known as "shock loads") call for an immediate response.

Industrial wastewater disinfection chemical procedures require careful balancing of cost and effectiveness against the possibility of producing hazardous chemical byproducts. The continuous transition to non-chlorine oxidants, such as PAA and ozone, highlights a growing dedication to not just getting rid of current infections but also making sure that the cleaning chemicals don't unintentionally turn into the next environmental hazard.

VI. EFFECT OF CHEMICALS AFTER CHEMICAL PROCESS IN DISINFECTION OF IWWTPs

Making toxic wastewater environmentally benign is a crucial, frequently contradictory objective that IWWTP operates under. Chemicals are the quick fix for the last crucial stage, disinfection, which eliminates germs and adheres to stringent discharge regulations. However, this essential purification process comes at a high cost, creating a "shadow chemistry" in which the purifying agents themselves turn into new pollutants.

After the final bacterium dies, the disinfection process continues. Due of the chemicals' lingering presence and subsequent interactions, it keeps developing in the receiving watercourse. A key component of sustainable water management is comprehending this aftermath. At its core, disinfection is a very active chemical reaction. Conventional techniques use strong oxidizers, such as chlorine (Cl_2), peracetic acid (PAA), ozone (O_3), and chloramines. These substances were picked because they break down microbial cell membranes quickly and effectively.

These oxidizers' lack of selectivity is the issue. They target dangerous bacteria while also reacting with all other substances found in the intricate, organic matrix of industrial wastewater, such as dissolved organic carbon (DOC), dyes, residual surfactants, and unspent feedstock chemicals.

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When the treated water is eventually discharged, it contains a variety of newly created compounds in addition to any remaining disinfectant. At this point, the short-term advantages of disinfection give way to long-term risks to the environment and public health.

1. Disinfection Byproducts' Imminent Danger (DBPs)

- The creation of disinfection byproducts (DBPs) is the most important effect of disinfection chemistry. These are the unexpected outcomes of the interaction between natural or artificial organic matter and the main disinfectant, particularly chlorine.
- Because industrial effluent has a significantly more concentrated and diversified chemical fingerprint than municipal sewage, DBP production is frequently made worse in these circumstances.
- Trihalomethanes (THMs) and Haloacetic Acids (HAAs): These are the most researched classes of DBPs and are produced nearly solely by the reaction of free chlorine with organic precursors. Their amounts in industrial discharges can be concerning, despite the fact that drinking water is heavily regulated. Many DBPs provide a cumulative risk to downstream communities that use the same water supply since they are categorized as probable human carcinogens or endocrine disruptors.
- Iodinated and Brominated Compounds: Chlorination can produce extremely hazardous brominated and iodinated DBPs if the industrial process uses brackish water or if the waste stream contains a lot of iodide or bromide ions. Generally speaking, these are more hazardous than their chlorinated equivalents.

2. Ecosystem Shock and Residual Toxicity

The existence of the leftover disinfectant is the most basic chemical consequence following treatment. Maintaining a certain chemical concentration for an adequate contact time (CT value) is necessary for a successful disinfection procedure. This implies that when the water exits the contact basin, there must unavoidably be a detectable level of free chlorine or residual oxidizer.

This extremely reactive chemical residue functions as a shock agent when it gets into a lake, river, or coastal environment:

- Impact on Aquatic Life: Fish, amphibians, and delicate macroinvertebrates are among the aquatic creatures that are profoundly poisoned by residual chlorine. It disrupts respiration and gill function. The entire aquatic food chain depends on delicate species like zooplankton, and even low parts-per-million concentrations can interfere with vital functions.
- Inhibition of Natural Attenuation: By sterilizing the receiving environment, residual disinfectants might destroy beneficial microbial communities that are essential for the organic breakdown and decomposition of other contaminants. The receiving body's capacity to detoxify itself is hampered by this.

3. The Industrial Setting: An Ongoing Obstacle

Two characteristics of industrial wastewater make it particularly difficult to manage chemical aftermath: complexity and variability.

- Industrial facilities, such as textile mills, petrochemical plants, and pharmaceutical manufacturers, have effluent streams that are distinguished by particular, extremely durable compounds, in contrast to municipal plants. High amounts of complicated chemicals that react erratically with chlorine in a pharmaceutical factory can produce new, poorly understood DBPs. Because the wastewater from a dye producer contains a lot of color compounds, it requires a higher dose of oxidant, which ensures a larger chemical residue.

Standard dechlorination procedures frequently fail due to this chemical complexity, necessitating advanced modeling and analysis to precisely forecast the downstream effects. The ultimate objective of disinfecting industrial wastewater is to preserve human health without contaminating the environment. This calls for a change in emphasis from efficacy to aftermath sustainability.

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1. Dechlorination is required

- Controlled quenching is the most basic remedy for residual toxicity. Prior to release, treated water needs to be dechlorinated, which is usually accomplished by adding a reducing agent like sodium sulfite (Na_2SO_3), sulfur dioxide (SO_2), or sodium bisulfite ($NaHSO_3$).
- By neutralizing the hazardous free chlorine, these reductants produce innocuous chloride ions. This phase, which serves as an essential chemical safety barrier prior to the release point, is non-negotiable for advanced industrial plants.

2. Cutting-Edge Disinfection Technologies

Many industrial facilities are shifting to methods that reduce chemical inputs in order to completely avoid DBP formation:

- Ultraviolet (UV) disinfection: Without leaving any chemical residues in the water, UV light physically breaks down pathogen DNA. Despite its great effectiveness, UV requires very clear water (low turbidity) and leaves no protective behind in the outflow, thus it may be used in conjunction with a little amount of a residual disinfectant, such as chloramines.
- Advanced Oxidation Processes (AOPs): These systems, which frequently involve hydrogen peroxide and UV or ozone and UV, produce hydroxyl radicals (•OH), which are extremely powerful but transient oxidizers. AOPs can efficiently eliminate DBP precursors and resistant bacteria, resulting in cleaner effluent with lower reactivity later on.

One well-known environmental conundrum is the impact of the chemicals used in industrial disinfection. Although they are vital public health instruments, they also contribute to ongoing contamination. The chemical load on receiving waters and treatment plants rises with the complexity of industrial operations. Killing the germs is only one aspect of sustainable water management; another is controlling the poisonous shadow, or ghost chemistry, that the therapy leaves behind.

VII. A CASE STUDY ON THE INDUSTRIAL WASTEWATER TREATMENT PLANT OF "NOVACHEM SOLUTIONS"

Any industrial facility is characterized by the hum of equipment, the complex dance of pipes, and the steady flow of liquids. However, a subtle but vital process is taking place beneath the surface of production: wastewater treatment. Without it, our planet's valuable water resources would suffer unsustainable consequences as a result of the very advancement that companies aim for. The Wastewater Treatment Plant (WWTP) of NovaChem Solutions, a shining example of how environmental responsibility and industrial innovation may coexist, is the focus of this case study.

One of the biggest producers of specialty chemicals, NovaChem Solutions, has a big problem. Despite being essential for many downstream sectors, their production procedures produced a complicated effluent discharge. A wide variety of contaminants were present in this wastewater, including:

- Organic compounds: Cleaning agents, leftovers, and residual reactants.
- Inorganic salts: Sulfates, chlorides, and nitrates in varying amounts.
- Heavy metals: Copper, zinc, and nickel traces from equipment wear and catalyst use.
- pH fluctuations: Depending on the particular chemical process, discharges can be extremely acidic or alkaline. Fine particles produced during reactions and filtering are known as suspended solids.

Directly releasing this untreated wastewater into the nearby river would have had disastrous effects, including eutrophication from too many nutrients, aquatic life toxicity from heavy metals and organic compounds, and harm to water users downstream.

NovaChem made an investment in a cutting-edge WWTP after realizing how important it was to manage wastewater responsibly. Their strategy was a multi-stage, meticulously planned procedure intended to properly address each pollutant category rather than a one-size-fits-all approach.

Stage 1: Pre-treatment: Screening and grit removal mark the start of the process. Mechanical screens capture large material, such as plastics and rags, preventing downstream equipment damage. Then, larger inorganic materials, such as

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gravel and sand, can settle out in grit chambers. This phase is essential for safeguarding the subsequent, more delicate biological processes.

Stage 2: Primary Treatment: The wastewater goes into primary sedimentation tanks after pre-treatment. Because the flow is slowed here, lighter materials like oils and grease can float to the top and be skimmed off, while heavier suspended solids can sink to the bottom as sludge. The organic load and suspended solids entering the following step are greatly decreased as a result.

Stage 3: Secondary Treatment. NovaChem uses a reliable biological treatment technique called activated sludge. The dissolved organic stuff in the wastewater feeds a carefully managed community of microorganisms that flourish in vast aeration tanks. Because oxygen is constantly available, these microorganisms may quickly absorb and decompose the organic contaminants into simpler, innocuous compounds like water and carbon dioxide. In order to preserve a healthy microbial population, the treated wastewater is separated from the sludge in secondary clarifiers, where the mixed liquor is then partially recycled back to the aeration tanks.

Stage 4: Tertiary Treatment: Although secondary treatment greatly purifies the water, additional polishing was required due to NovaChem's dedication to going above and beyond legal requirements. This phase consists of:

- Chemical Precipitation/Flocculation: Chemicals are given to the suspended particles to encourage the metals to bind to them, creating larger flocs that are easier to settle out. This process removes any remaining heavy metals.
- Filtration: Multi-media filters guarantee a pure effluent by eliminating any last traces of tiny suspended materials.
- Disinfection: To make the water safe for release, any dangerous microorganisms or pathogens that may still be present are rendered inactive by ultraviolet (UV) radiation or chlorination.

Step 5: Handling Sludge: The sludge produced throughout the procedure is not only thrown away. Anaerobic digestion has been used by NovaChem. The organic matter in the sludge is broken down by specialist bacteria in the absence of oxygen, creating biogas, a renewable energy source mainly made up of methane. The WWTP's energy footprint and operating expenses are greatly decreased when this biogas is captured and used to create electricity. After being dewatered, the residual stabilized sludge can either be securely disposed of or utilized as a soil conditioner, depending on its makeup.

NovaChem's WWTP has had a significant impact:

- Environmental Protection: The treated wastewater that is released into the river regularly satisfies and frequently surpasses strict environmental standards, safeguarding downstream water quality and aquatic life.
- Resource Recovery: The WWTP's energy requirements are largely met by the biogas produced from sludge digestion, which lessens dependency on fossil fuels and lowers operating expenses.
- Economic Viability: Despite the considerable initial outlay, the WWTP has shown to be a wise financial choice because to its potential for resource recovery, lower environmental penalties, and long-term energy savings.
- Social Responsibility: By establishing a solid reputation as an ecologically conscientious business, NovaChem has gained the trust of stakeholders and the local community.

The WWTP at NovaChem is proof of the effectiveness of integrated design and ongoing development. Important lessons discovered include:

- Knowing the Effluent: Creating an efficient treatment system requires a detailed description of the wastewater stream.
- Modular Design: A multi-phase process enables adaptability and flexibility to shifting environmental requirements and production demands.
- Embracing Innovation: A cost center can become a value producer by investigating cutting-edge treatment technology and resource recovery solutions.
- Operational Excellence: For plants to operate at their best, regular monitoring, knowledgeable staff, and preventative maintenance are essential.

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In order to achieve a genuinely circular economy model, NovaChem is looking at future developments, such as membrane filtration for even better effluent quality and the possibility of recycling and reusing water in their production processes. More than just a building, NovaChem Solutions' industrial wastewater treatment plant is an unsung hero that works nonstop behind the scenes to protect the environment, preserve valuable resources, and guarantee that ecological health and industrial advancement may coexist together. It is a potent reminder that taking good care of our world is not a chore but rather a chance to be creative and dedicated to a sustainable future.

VIII. CONCLUSION

A wider social recognition of limited resources and the necessity of environmental stewardship is reflected in the development of industrial wastewater treatment plants. The difficulties are still significant, especially when it comes to the financial obstacles to reaching Zero Liquid Discharge (ZLD) and reducing complex, non-biodegradable contaminants (such microplastics and PFAS). Nonetheless, three crucial convergent themes steer the trajectory, which is resolutely forward-looking:

1. Digital Integration: IWWTP operations are moving from reactive management to proactive optimization as a result of the use of IoT sensors, predictive analytics, and artificial intelligence (AI). Operators can significantly increase efficiency and lessen their total environmental impact by anticipating load changes, optimizing chemical dosing, and minimizing energy use through the use of digital twins and modeling simulations.
2. The Resource Imperative: The ability of future IWWTPs to extract resources will be their primary defining characteristic. In order to turn waste streams into useful input commodities, standard operational metrics will include water reuse (treating effluent to near-potable standards for industrial processes), nutrient recovery (phosphorus and nitrogen), and optimizing energy harvesting from sludge.
3. Global Standardization: As business grows more interconnected, standardized, strict regulatory frameworks that require best available techniques (BATs) and enforce responsibility across global supply chains are becoming more and more necessary.

In conclusion, the unseen guardians preserving the integrity of our water systems are industrial wastewater treatment plants. Their efficacy is a key component of environmental resilience and a gauge of true corporate responsibility. Whether industrial development stays within sustainable ecological bounds will ultimately depend on how well these cutting-edge facilities are scaled and strategically implemented, providing a crucial route to the Anthropocene's long-term prosperity.

REFERENCES

[1]. Ashit Gaikwad, Amogsidha Chendke, Nizam Mulani, and Mangrule Sarika, “Submersible Pump Theft Indicator”, IEJRD - International Multidisciplinary Journal, vol. 5, no. 4, p. 5, May 2020. Available at: https://www.iejrd.com/index.php/%20/article/view/627

[2]. Mr. Akhilesh Raut, Mr. Mahesh Mali, Miss. Trupti Mashale, Prof. Kazi K. S. (2018). Bagasse Level Monitoring System, International Journal of Trend in Scientific Research and Development (ijtsrd), Volume-2, Issue-3, April 2018, pp.1657-1659, URL: https://www.ijtsrd.com/papers/ijtsrd11469.pdf

[3]. Altaf Osman Mulani, Rajesh Maharudra Patil “Discriminative Appearance Model For Robust Online Multiple Target Tracking”, Telematique, 2023, Vol 22, Issue 1, pp. 24- 43.

[4]. M Sunil Kumar, D Ganesh, Anil V Turukmane, Umamaheswararao Batta, ,”Deep Convolution Neural Network based solution for detecting plant Diseases”, Journal of Pharmaceutical Negative Results, 2022, Vol 13, Special Issue- I, pp. 464-471,

[5]. Halli U M, “Nanotechnology in IoT Security”, Journal of Nanoscience, Nanoengineering & Applications, 2022, Vol 12, issue 3, pp. 11 – 16.

[6]. Wale Anjali D., Rokade Dipali, et al, “Smart Agriculture System using IoT”, International Journal of Innovative Research In Technology, 2019, Vol 5, Issue 10, pp.493 - 497.

[7]. Kazi K. S., "Significance And Usage Of Face Recognition System", Scholarly Journal For Humanity Science and English Language, 2017, Vol 4, Issue 20, pp. 4764 - 4772.

[8]. Miss. A. J. Dixit, et al, "Iris Recognition by Daugman's Method", International Journal of Latest Technology in Engineering, Management & Applied Science, 2015, Vol 4, Issue 6, pp 90 - 93.

[9]. Kazi K S L, "Significance of Projection and Rotation of Image in Color Matching for High-Quality Panoramic Images used for Aquatic study", International Journal of Aquatic Science, 2018, Vol 09, Issue 02, pp. 130 – 145.

[10]. Halli U.M., "Nanotechnology in E-Vehicle Batteries", International Journal of Nanomaterials and Nanostructures. 2022; Vol 8, Issue 2, pp. 22–27.

[11]. Pankaj R Hotkar, Vishal Kulkarni, et al, "Implementation of Low Power and area efficient carry select Adder", International Journal of Research in Engineering, Science and Management, 2019, Vol 2, Issue 4, pp. 183 - 184.

[12]. Kazi K S, "Detection of Malicious Nodes in IoT Networks based on Throughput and ML", Journal of Electrical and Power System Engineering, 2023, Volume-9, Issue 1, pp. 22- 29.

[13]. Karale Nikita, Jadhav Supriya, et al, "Design of Vehicle system using CAN Protocol", International Journal of Research in Applied science and Engineering Technology, 2020, Vol 8, issue V, pp. 1978 - 1983, http://doi.org/10.22214/ijraset.2020.5321. Available at: https://www.ijraset.com/fileserve.php?FID=28817

[14]. K. Kazi, "Lassar Methodology for Network Intrusion Detection", Scholarly Research Journal for Humanity science and English Language, 2017, Vol 4, Issue 24, pp.6853 - 6861.

[15]. Miss Argonda U A, "Review paper for design and simulation of a Patch antenna by using HFSS", International Journal of Trends in Scientific Research and Development, 2018, Vol 2, issue-2, pp. 158 - 160.

[16]. Kazi K., "Hybrid optimum model development to determine the Break", Journal of Multimedia Technology & Recent Advancements, 2022, vol 9, issue 2, pp. 25 – 33. Available at: https://stmcomputers.stmjournals.com/index.php/JoMTRA/article/view/402

[17]. Kazi K., "Reverse Engineering's Neural Network Approach to human brain", Journal of Communication Engineering & Systems, 2022, vol 12, issue 2, pp. 17 – 24.

[18]. Miss. A. J. Dixit, et al, "A Review paper on Iris Recognition", Journal GSD International society for green, Sustainable Engineering and Management, 2014, Vol 1, issue 14, pp. 71 - 81.

[19]. Ms. Shweta Nagare, et al., "An Efficient Algorithm brain tumor detection based on Segmentation and Thresholding", Journal of Management in Manufacturing and services, 2015, Vol 2, issue 17, pp.19 - 27.

[20]. Kazi K., "Model for Agricultural Information system to improve crop yield using IoT", Journal of open Source development, 2022, vol 9, issue 2, pp. 16 – 24.

[21]. Miss. A. J. Dixit, et al, "Iris Recognition by Daugman's Algorithm – an Efficient Approach", Journal of applied Research and Social Sciences, 2015, Vol 2, issue 14, pp. 1 - 4.

[22]. Shirgan S S, " Face Recognition based on Principal Component Analysis and Feed Forward Neural Network", National Conference on Emerging trends in Engineering, Technology, Architecture, 2010, pp. 250 - 253.

[23]. Ms. Yogita Shirdale, et al., "Coplanar capacitive coupled probe fed micro strip antenna for C and X band", International Journal of Advanced Research in Computer and Communication Engineering, 2016, Vol 5, Issue 4, pp. 661 - 663.

[24]. Ravi Aavula, Amar Deshmukh, V A Mane, et al, "Design and Implementation of sensor and IoT based Remembrance system for closed one", Telematique, 2022, Vol 21, Issue 1, pp. 2769 - 2778.

[25]. Salunke Nikita, et al, "Announcement system in Bus", Journal of Image Processing and Intelligent remote sensing, 2022, Vol 2, issue 6.

[26]. Madhupriya Sagar Kamuni, et al, "Fruit Quality Detection using Thermometer", Journal of Image Processing and Intelligent Remote Sensing, 2022, Vol 2, Issue 5.

[27]. Shweta Kumtole, et al, " Automatic wall painting robot Automatic wall painting robot", Journal of Image Processing and Intelligent remote sensing, 2022, Vol 2, issue 6

[28]. Kadam Akansha, et al, "Email Security", Journal of Image Processing and Intelligent remote sensing, 2022, Vol 2, issue 6.

[29]. K. Kazi, "Systematic Survey on Alzheimer (AD) Diseases Detection", 2022.

[30]. K. Kazi, "A Review paper Alzheimer", 2022.

[31]. Mrunal M Kapse, et al, "Smart Grid Technology", International Journal of Information Technology and Computer Engineering, Vol 2, Issue 6 .

[32]. Satpute Pratiskha Vaijnath, Mali Prajakta et al. "Smart safty Device for Women", International Journal of Aquatic Science, 2022, Vol 13, Issue 1, pp. 556 - 560.

[33]. Miss. Priyanka M Tadlagi, et al, "Depression Detection", Journal of Mental Health Issues and Behavior (JHMIB), 2022, Vol 2, Issue 6, pp. 1 – 7.

[34]. Waghmare Maithili, et al, "Smart watch system", International journal of information Technology and computer engineering (IJITC), 2022, Vol 2, issue 6, pp. 1 - 9.

[35]. Prof. Kazi Kutubuddin S. L., "Situation Invariant face recognition using PCA and Feed Forward Neural network", Proceeding of International Conference on Advances in Engineering, Science and Technology, 2016, pp. 260- 263.

[36]. Prof. Kazi Kutubuddin S. L., "An Approach on Yarn Quality Detection for Textile Industries using Image Processing", Proceeding of International Conference on Advances in Engineering, Science and Technology, 2016, pp. 325-330.

[37]. Divya Swami, et al, "Sending notification to someone missing you through smart watch", International journal of information Technology & computer engineering (IJITC), 2022, Vol 2, issue 8, pp. 19 – 24.

[38]. Shreya Kalmkar, Afrin, et al., " 3D E-Commers using AR", International Journal of Information Technology & Computer Engineering (IJITC), 2022, Vol 2, issue 6, pp. 18-27.

[39]. Kazi Kutubuddin S. L., "Predict the Severity of Diabetes cases, using K-Means and Decision Tree Approach", Journal of Advances in Shell Programming, 2022, Vol 9, Issue 2, pp. 24-31.

[40]. K. K. Sayyad Liyakat, "Nanotechnology Application in Neural Growth Support System", Nano Trends: A Journal of Nanotechnology and Its Applications, 2022, Vol 24, issue 2, pp. 47 – 55.

[41]. Kazi Kutubuddin S. L., "A novel Design of IoT based 'Love Representation and Remembrance' System to Loved One's", Gradiva Review Journal, 2022, Vol 8, Issue 12, pp. 377 - 383.

[42]. Sakshi M. Hosmani, et al., "Implementation of Electric Vehicle system", Gradiva Review Journal, 2022, Vol 8, Issue 12, pp. 444 – 449.

[43]. K. K., "Multiple object Detection and Classification using sparsity regularized Pruning on Low quality Image/ video with Kalman Filter Methodology (Literature review)", 2022.

[44]. K. Kazi, "Smart Grid energy saving technique using Machine Learning" Journal of Instrumentation Technology and Innovations, 2022, Vol 12, Issue 3, pp. 1 – 10.

[45]. Kazi Kutubuddin S. L., "Business Mode and Product Life Cycle to Improve Marketing in Healthcare Units", E-Commerce for future & Trends, 2022, vol 9, issue 3, pp. 1-9.

[46]. Dr. A. O. Mulani, "Effect of Rotation and Projection on Real time Hand Gesture Recognition system for Human Computer Interaction", Journal of The Gujrat Research Society, 2019, Vol 21, issue 16, pp. 3710 – 3718.

[47]. Kazi K S, "IoT based Healthcare system for Home Quarantine People", Journal of Instrumentation and Innovation sciences, 2023, Vol 8, Issue 1, pp. 1- 8.

[48]. Ms. Machha Babitha, C Sushma, et al, "Trends of Artificial Intelligence for online exams in education", International journal of Early Childhood special Education, 2022, Vol 14, Issue 01, pp. 2457-2463.

[49]. Dr. J. Sirisha Devi, Mr. B. Sreedhar, et al, "A path towards child-centric Artificial Intelligence based Education", International Journal of Early Childhood special Education, 2022, Vol 14, Issue 03, pp. 9915-9922.

[50]. Mr. D. Sreenivasulu, Dr. J. Sirishadevi, et al, "Implementation of Latest machine learning approaches for students Grade Prediction", International Journal of Early Childhood special Education, 2022, Vol 14, Issue 03, pp. 9887-9894.

[51]. Nilima S. Warhade, Rahul S. Pol, Hemlata M. Jadhav, Altaf O. Mulani, "Yarn Quality detection for Textile Industries using Image Processing", Journal of Algebraic Statistics, 2022, Vol 13, Issue 3, pp. 3465-3472.

[52]. Rahul S. Pole, Amar Deshmukh, Makarand Jadhav, et al, "iButton Based Physical access Authorization and security system", Journal of Algebraic Statistics, 2022, Vol 13, issue 3, pp. 3822-3829.

[53]. V A Mane, Dr K P Pardeshi, Dr. D.B Kadam, Dr. Pandyaji K K, "Development of Pose invariant Face Recognition method based on PCA and Artificial Neural Network", Journal of Algebraic Statistics, 2022, Vol 13, issue 3, pp. 3676-3684.

[54]. Dr. K. P. Pardeshi et al, "Development of Machine Learning based Epileptic Seizureprediction using Web of Things (WoT)" , NeuroQuantology, 2022, Vol 20, Issue 8, pp. 9394- 9409.

[55]. Dr. K. P. Pardeshi et al, "Implementation of Fault Detection Framework for Healthcare Monitoring System Using IoT, Sensors in Wireless Environment", Telematique, 2022, Vol 21, Issue 1, pp. 5451 – 5460.

[56]. Dr. B. D. Kadam et al, "Implementation of Carry Select Adder (CSLA) for Area, Delay and Power Minimization", Telematique, 2022, Vol 21, issue 1, pp. 5461 – 5474.

[57]. Kazi K S L, "IoT-based weather Prototype using WeMos", Journal of Control and Instrumentation Engineering, 2023, Vol 9, Issue 1, pp. 10 – 22.

[58]. Kazi Kutubuddin, "Detection of Malicious Nodes in IoT Networks based on packet loss using ML", Journal of Mobile Computing, Communication & mobile Networks, 2022, Vol 9, Issue 3, pp. 9 -16.

[59]. Kazi Kutubuddin, "Big data and HR Analytics in Talent Management: A Study", Recent Trends in Parallel Computing, 2022, Vol 9, Issue 3, pp. 16-26.

[60]. Kazi K S, "IoT-Based Healthcare Monitoring for COVID-19 Home Quarantined Patients", Recent Trends in Sensor Research & Technology, 2022, Vol 9, Issue 3. pp. 26 – 32.

[61]. Gouse Mohiuddin Kosgiker, "Machine Learning- Based System, Food Quality Inspection and Grading in Food industry", International Journal of Food and Nutritional Sciences, 2018, Vol 11, Issue 10, pp. 723- 730.

[62]. U M Halli, Voltage Sag Mitigation Using DVR and Ultra Capacitor. Journal of Semiconductor Devices and Circuits. 2022; 9(3): 21–31p.

[63]. Kazi Kutubuddin, "Blockchain-Enabled IoT Environment to Embedded System a Self-Secure Firmware Model", Journal of Telecommunication study, 2023, Vol 8, Issue 1.

[64]. Kazi Kutubuddin, "A Study HR Analytics Big Data in Talent Management", Research and Review: Human Resource and Labour Management, 2023, Volume-4, Issue-1, pp. 16-28.

[65]. Narender Chinthamu, M. Prasad, "Self-Secure firmware model for Blockchain-Enabled IOT environment to Embedded system", Eur. Chem. Bull., 2023, 12(S3), pp. 653 – 660. DOI:10.31838/ecb/2023.12.s3.075

[66]. Vahida, et al, "Deep Learning, YOLO and RFID based smart Billing Handcart", Journal of Communication Engineering & Systems, 2023, 13(1), pp. 1-8.

[67]. Kazi Kutubuddin Sayyad Liyakat, "Analysis for Field distribution in Optical Waveguide using Linear Fem method", Journal of Optical communication Electronics, 2023, Vol 9, Issue 1, pp. 23- 28.

[68]. Miss. Mamdyal, Miss. Sandupatia, et al, "GPS Tracking System", International Journal of Advanced Research in Science, Communication and Technology (IJARSCT), 2022, Vol 2, issue- 1, pp. 2492 – 2529, Available at: https://ijarsct.co.in/A7317.pdf

[69]. Rajesh Maharudra Patil, "Modelo De Apariencia Discriminatorio Para Un Sólido Seguimiento En Línea De Múltiples Objetivos", Telematique, 2023, Vol 22, Issue 1, pp. 24- 43.

[70]. Karale Aishwarya A, et al, "Smart Billing Cart Using RFID, YOLO and Deep Learning for Mall Administration", International Journal of Instrumentation and Innovation Sciences, 2023, Vol 8, Issue- 2.

[71]. Suryawanshi Rupali V, "Situation Invariant face recognition using Neural Network", International Journal of Trends in Scientific research and Development, 2018, Vol 2, pp. 995-998.

[72]. Sultanabanu Kazi, et al.(2023), Fruit Grading, Disease Detection, and an Image Processing Strategy, Journal of Image Processing and Artificial Intelligence, 9(2), 17-34.

[73]. Sultanabanu Kazi, Mardanali Shaikh, "Machine Learning in the Production Process Control of Metal Melting" Journal of Advancement in Machines, Volume 8 Issue 2 (2023).

[74]. Kazi Kutubuddin Sayyad Liyakat, "IoT based Smart HealthCare Monitoring", In: Rhituraj Saikia (eds), Liberation of Creativity: Navigating New Frontiers in Multidisciplinary Research, Vol. 2, July 2023, pp. 456- 477, ISBN: 979-8852143600

[75]. Kazi Kutubuddin Sayyad Liyakat, "IoT based Substation Health Monitoring", In: Rhituraj Saikia (eds), Magnification of Research: Advanced Research in Social Sciences and Humanities, Volume 2, October 2023, pp. 160 – 171, ISBN: 979-8864297803

[76]. Priya Mangesh Nerkar, Sunita Sunil Shinde, et al, "Monitoring Fresh Fruit and Food Using IoT and Machine Learning to Improve Food Safety and Quality", Tuijin Jishu/Journal of Propulsion Technology, Vol. 44, No. 3, (2023) , pp. 2927 – 2931.

[77]. Kazi Sultanabanu Sayyad Liyakat (2023). Integrating IoT and Mechanical Systems in Mechanical Engineering Applications, Journal of Mechanical Robotics, 8(3), 1-6.

[78]. Kazi Sultanabanu Sayyad Liyakat (2023). IoT Changing the Electronics Manufacturing Industry, Journal of Analog and Digital Communications, 8(3), 13-17.

[79]. Kazi Sultanabanu Sayyad Liyakat (2023). IoT in the Electric Power Industry, Journal of Controller and Converters, 8(3), 1-7.

[80]. Kazi Sultanabanu Sayyad Liyakat (2023). Review of Integrated Battery Charger (IBC) for Electric Vehicles (EV), Journal of Advances in Electrical Devices, 8(3), 1-11.

[81]. Kazi Sultanabanu Sayyad Liyakat (2023). ML in the Electronics Manufacturing Industry, Journal of Switching Hub, 8(3), 9-13.

[82]. Kazi Sultanabanu Sayyad Liyakat (2023). IoT in Electrical Vehicle: A Study, Journal of Control and Instrumentation Engineering, 9(3), 15-21.

[83]. Kazi Sultanabanu Sayyad Liyakat (2023). PV Power Control for DC Microgrid Energy Storage Utilisation, Journal of Digital Integrated Circuits in Electrical Devices, 8(3), 1-8.

[84]. Kazi Sultanabanu Sayyad Liyakat (2023). Electronics with Artificial Intelligence Creating a Smarter Future: A Review, Journal of Communication Engineering and Its Innovations, 9(3), 38-42.

[85]. Kazi Sultanabanu Sayyad Liyakat (2023). Dispersion Compensation in Optical Fiber: A Review, Journal of Telecommunication Study, 8(3), 14-19.

[86]. Kazi Sultanabanu Sayyad Liyakat (2023). IoT Based Arduino-Powered Weather Monitoring System, *Journal of Telecommunication Study*, 8(3), 25-31.

[87]. Kazi Sultanabanu Sayyad Liyakat (2023). Arduino Based Weather Monitoring System, *Journal of Switching Hub*, 8(3), 24-29.

[88]. V D Gund, et al. (2023). PIR Sensor-Based Arduino Home Security System, *Journal of Instrumentation and Innovation Sciences*, 8(3), 33-37.

[89]. Kazi Kutubuddin Sayyad Liyakat (2023), System for Love Healthcare for Loved Ones based on IoT. *Research Exploration: Transcendence of Research Methods and Methodology,* Volume 2, ISBN: 979-8873806584, ASIN : B0CRF52FSX

[90]. K K S Liyakat (2022). Implementation of e-mail security with three layers of authentication, *Journal of Operating Systems Development and Trends*, 9(2), 29-35.

[91]. Mishra Sunil B., et al. (2024). Nanotechnology's Importance in Mechanical Engineering, *Journal of Fluid Mechanics and Mechanical Design*, 6(1), 1-9.

[92]. Kazi Kutubuddin Sayyad Liyakat (2024). Blynk IoT-Powered Water Pump-Based Smart Farming, *Recent Trends in Semiconductor and Sensor Technology*, 1(1), 8-14.

[93]. Sultanabanu Sayyad Liyakat, (2024). IoT-based Alcohol Detector using Blynk, Journal of Electronics Design and Technology, 1(1), 10-15.

[94]. Kazi Sultanabanu Sayyad Liyakat, (2023). Accepting Internet of Nano-Things: Synopsis, Developments, and Challenges. Journal of Nanoscience, Nanoengineering & Applications. 2023; 13(2): 17–26p. DOI: https://doi.org/10.37591/jonsnea.v13i2.1464

[95]. Mishra Sunil B., et al. (2024). Review of the Literature and Methodological Structure for IoT and PLM Integration in the Manufacturing Sector, Journal of Advancement in Machines, 9(1), 1-5.

[96]. Mishra Sunil B., et al. (2024). AI-Driven IoT (AI IoT) in Thermodynamic Engineering, Journal of Modern Thermodynamics in Mechanical System, 6(1), 1-8.

[97]. Kazi Kutubuddin Sayyad Liyakat (2024). Impact of Solar Penetrations in Conventional Power Systems and Generation of Harmonic and Power Quality Issues, Advance Research in Power Electronics and Devices, 1(1), 10-16.

[98]. Sayyad Liyakat. Intelligent Watering System (IWS) for Agricultural Land Utilising Raspberry Pi. Recent Trends in Fluid Mechanics. 2023; 10(2): 26–31p.

[99]. Sunil Shivaji Dhanwe, et al. (2024). AI-driven IoT in Robotics: A Review, Journal of Mechanical Robotics, 9(1), 41-48.

[100]. Kazi Sultanabanu Sayyad Liyakat, Kazi Kutubuddin Sayyad Liyakat. Nanomedicine as a Potential Therapeutic Approach to COVID-19. International Journal of Applied Nanotechnology. 2023; 9(2): 27–35p. Available at: https://materials.journalspub.info/index.php?journal=IJAN&page=article&op=view&path%5B%5D=1038

[101]. **Megha Nagrale, Rahul S. Pol, Ganesh B. Birajadar, Altaf O. Mulani, (2024).** Internet of Robotic Things in Cardiac Surgery: An Innovative Approach, African Journal of Biological Sciences, Vol 6, Issue 6, pp. 709-725 doi: 10.33472/AFJBS.6.6.2024.709-725

[102]. *Kazi Kutubuddin Sayyad Liyakat, (2023).* IoT based Healthcare Monitoring for COVID- Subvariant JN-1, *Journal of Electronic Design Technology,* Vol 14, No 3 (2023).

[103]. *Kazi Kutubuddin Sayyad Liyakat (2023).* Smart Motion Detection System using IoT: A NodeMCU and Blynk Framework, Journal of Microelectronics and Solid State Devices, Vol 10, No 3 (2023).

[104]. Chopade Mallikarjun Abhangrao (2024), Internet of Things in Mechatronics for Design and Manufacturing: A Review, Journals of Mechatronics Machine Design and Manufacturing, Vol 6, Issue 1.

[105]. *Kazi Kutubuddin Sayyad Liyakat (2023).* Nanotechnology in Precision Farming: The Role of Research, *International Journal of Nanomaterials and Nanostructures*, Vol 9, No 2 (2023), https://doi.org/10.37628/ijnn.v9i2.1051

[106]. Kazi Kutubuddin Sayyad Liyakat. (2023). Home Automation System Based on GSM. *Journal of VLSI Design Tools & Technology*. 2023; 13(3): 7–12p. https://doi.org/10.37591/jovdtt.v13i3.7877

[107]. Prof. Suryawanshi Rupali Vithalrao,(2018). Situation invariant Face Recognition using Neural Networks, International Journal of Trend in Scientific Research and Development (IJTSRD), Vol 2, Issue 4, pp. .995-998, https://doi.org/10.31142/ijtsrd14162 Available at: URL: https://www.ijtsrd.com/papers/ijtsrd14162.pdf

[108]. *Kazi Kutubuddin Sayyad Liyakat, (2024).* Intelligent Watering System(IWS) for Agricultural Land Utilising Raspberry Pi, Recent Trends in Fluid Mechanics, Vol 10, No 2, pp. 26-31.

[109]. Kazi Kutubuddin Sayyad Liyakat (2024). IoT and Sensor-based Smart Agriculturing Driven by NodeMCU, *Research & Review: Electronics and Communication Engineering*, 1(2), 25-33. Available at: https://matjournals.net/engineering/index.php/RRECE/article/view/742

[110]. Kazi Kutubuddin Sayyad Liyakat (2024). Smart Agriculture based on AI-Driven-IoT(AIIoT): A KSK Approach, *Advance Research in Communication Engineering and its Innovations*, 1(2), 23-32. Available at: https://matjournals.net/engineering/index.php/ARCEI/article/view/746

[111]. K Kazi(2024). Complications with Malware Identification in IoT and an Overview of Artificial Immune Approaches. *Research & Reviews: A Journal of Immunology*. 2024; 14(01):54-62. Available from: https://journals.stmjournals.com/rrjoi/article=2024/view=144241

[112]. Nida N. Shaikh, Milind D. Chavan, V.G. Shirshikar,(2023). PV Penetrations in Conventional Power System and Generation of Harmonic and Power Quality Issues: A Review. *International Journal of Power Electronics Controllers and Converters*. 2023; 9(2): 12–19p. Available at: https://ecc.journalspub.info/index.php?journal=JPECC&page=article&op=view&path%5B%5D=1976

[113]. Vaibhav L. Jadhav, Arjun P. Shinde, (2024). Detection of Fire in the Environment via a Robot Based Fire Fighting System Using Sensors, International Journal of Advanced Research in Science, Communication and Technology (IJARSCT), Volume 4, Issue 4, pp. 410 – 418.

[114]. Kazi Kutubuddin Sayyad Liyakat (2024). Nanotechnology in Medical Applications: A Study. Nano Trends: A Journal of Nanotechnology and Its Applications. 2024; 26(2): 1–11p.

[115]. Kazi Kutubuddin Sayyad Liyakat. (2024). Nanotechnology in BattleField: A Study. Journal of Nanoscience, Nanoengineering & Applications. 2024; 14(2): 18–30p.

[116]. Sultananbanu Sayyad Liyakat Kazi, (2024). Polymer Applications in Energy Generation and Storage: A Forward Path. Journal of Nanoscience, Nanoengineering & Applications. 2024; 14(2): 31–39p.

[117]. Kazi Kutubuddin Sayyad Liyakat, (2024). Review of Biopolymers in Agriculture Application: An Eco-Friendly Alternative. International Journal of Composite and Constituent Materials. 2024; 10(1): 50–62p.

[118]. Kazi Kutubuddin Sayyad Liyakat (2024). Railway Health-Monitoring Using KSK Approach: Decision-Making Using AIIoT Approach in Railways, *Journal of Controller and Converters*, 9(3), 1-10. Available at: https://matjournals.net/engineering/index.php/JCC/article/view/1047

[119]. K K Sayyad Liyakat. (2024). Impact of Nanotechnology on Battlefield Welfare: A Study. International Journal of Nanobiotechnology. 2024; 10(2): 19– 32p.

[120]. Sultanabanu Sayyad Liyakat, (2024q). Nanotechnology in Healthcare Applications: A Study. International Journal of Nanobiotechnology. 2024; 10(2): 48–58p.

[121]. Kazi Kutubuddin Sayyad Liyakat (2024). A Study on AI-driven IoT (AIIoT) based Decision Making: KSK Approach in Robot for Medical Applications, Recent Trends in Semiconductor and Sensor Technology, 1(3), 1-17. Available at: https://matjournals.net/engineering/index.php/RTSST/article/view/1044

[122]. Kazi Kutubuddin Sayyad Liyakat (2024). Wireless Train Collision Avoidance System, Advance Research in Communication Engineering and its Innovations, 1(3), 16-25.

[123]. Kazi Kutubuddin Sayyad Liyakat. (2024). Internet of Battlefield Things: An IoBT-inspired Battlefield of Tomorrow. *Journal of Telecommunication, Switching Systems and Networks*. 2024; 11(3): 11–19p.

[124]. Sunil B. Mishra (2024d). AI-Driven-IoT (AIIoT)-Based Decision Making in Manufacturing Processes in Mechanical Engineering, Journal of Mechanical Robotics, 9(2), 27-38.

[125]. Sunil B. Mishra (2024e). AI-Driven-IoT (AIIoT) Based Decision-Making in Molten Metal Processing, Journal of Industrial Mechanics, 9(2), 45-56.

[126]. Kazi Kutubuddin Sayyad Liyakat, Impact of Nanotechnology on Battlefield Welfare: A Study. International journal of Nanobiotechnology. 2024; 10(02): 19-32p.

[127]. Kazi Sultanabanu Sayyad Liyakat and Kazi Kutubuddin Sayyad Liyakat, Nanosensors in Agriculture Field: A Study. International Journal of Applied Nanotechnology. 2024; 10(02): 12-22p. Available from:https://journalspub.com/publication/ijan-v10i02-11625/

[128]. Kazi Kutubuddin Sayyad Liyakat, Nanotechnology in Space Study. International Journal of Applied Nanotechnology. 2024; 10(02): 39-46p. Available from:https://journalspub.com/publication/ijan-v10i02-11616/

[129]. Dr. Kazi Kutubuddin Sayyad Liyakat. (2024). KSK Approach to Smart Agriculture: Utilizing AI-Driven Internet of Things (AI IoT). *Journal of Microcontroller Engineering and Applications.* 2024; 11(03):21-32.

[130]. Kazi Kutubuddin Sayyad Liyakat. (2024). Microwave Communication in the Internet of Things: A Study. *Journal of RF and Microwave Communication Technologies*, 38–49. Retrieved from https://matjournals.net/engineering/index.php/JoRFMCT/article/view/1276

[131]. K*azi Kutubuddin Sayyad Liyakat, (2023).* Nanorobotics: A Review, *International Journal of Applied Nanotechnology (IJAN),* 9(2), pp. 36 – 43. DOI: https://doi.org/10.37628/ijan.v9i2.1019

[132]. Dr. Kazi Kutubuddin Sayyad Liyakat. Sensor and IoT centered Smart Agriculture by NodeMCU. Recent Trends in Sensor Research & Technology. 2024; 11(03):24-32. Available from: https://journals.stmjournals.com/rtsrt/article=2024/view=179744

[133]. Kazi Kutubuddin Sayyad Liyakat.(2024). Carbon based Supercapacitor for Electric Vehicles. Journal of Nanoscience, NanoEngineering & Applications. 2024; 14(03):01-11. Available from: https://journals.stmjournals.com/jonsnea/article=2024/view=179371.

[134]. G M Kosgiker. Satellite Sensing for Sea Level Monitoring: A Transformative Approach to Understanding Climate Change. *Journal of Microwave Engineering & Technologies*. 2025; 12(1): 33–41p.

[135]. Kazi Kutubuddin Sayyad Liyakat. Transforming IoT Connectivity Through VLSI Technology. International Journal of VLSI Circuit Design & Technology. 2024; 02(02):1-11. Available from: https://journals.stmjournals.com/ijvcdt/article=2024/view=190803

[136]. Kazi Kutubuddin Sayyad Liyakat, "Internet of Robotics Things in Industrial Applications: A Study," Journal of Control and Instrumentation Engineering, vol. 11, no. 1, pp. 1-10, Feb 2025.

[137]. Kazi Kutubuddin Sayyad Liyakat. Fake Cryptocurrecy Detection using Python. Recent Trends in Programming Languages. 2025; 12(1): 1–7p.

[138]. Kazi Kutubuddin Sayyad Liyakat. The Future is Smelling: Exploring the Potential of e-Nose. Journal of Semiconductor Devices and Circuits. 2025; 12(1): 16–27p.

[139]. Sultanabanu Sayyad Liyakat. (2025). Quantum Key Distribution in Optical Fiber Communication: A Study. *Trends in Opto-electro & Optical Communication*. 2025; 15(1): 30–40p.

[140]. Sayyad Liyakat. Fake Cryptocurrency Detection Using Python. Recent Trends in Programming languages. 2025; 12(01):1-7. Available from: https://journals.stmjournals.com/rtpl/article=2025/view=201421

[141]. Kutubuddin, **KSK Approach in LOVE Health: AI-Driven- IoT(AIIoT) based Decision Making System in LOVE Health for Loved One,** *GRENZE International Journal of Engineering and Technology,* 2025, 11(1), pp. 4628-4635. Grenze ID: 01.GIJET.11.1.371_1

[142]. Kazi Kutubuddin Sayyad Liyakat. TensorFlow- Based Big Data Analytics for IoT Networks: A Study. *International Journal of Data Structure Studies*. 2025; 3(1): 32–40p.

[143]. Kazi Kutubuddin Sayyad Liyakat. Brand Protection Using Machine Learning: A New Era. *E-Commerce for Future & Trends*. 2025; 12(1): 33-44p.

[144]. Dhanve and Liyakat, "Machine Learning Forges a New Future for Metal Processing: A Study," International Journal of Artificial Intelligence in Mechanical Engineering, vol. 1, no. 1, pp. 1-12, Mar. 2025.

[145]. Kutubuddin Sayyad Liyakat. e-Skin Applications in Healthcare and Robotics: A Study. Journal of Advancements in Robotics. 2025; 12(1):13 –21p.

[146]. Kutubuddin Sayyad Liyakat. Millimeter Wave in Internet of Things Connectivity: A Study. *International Journal of Wireless Security and Networks*. 2025; 03(01):13-23.

[147]. Kutubuddin Sayyad Liyakat. TensorFlow-Based Big Data Analytics for IoT Networks: A Study. *International Journal of Data Structure Studies.* 2025; 03(01):31-38.

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[148]. Kutubuddin Sayyad Liyakat. Multimedia Technology in Healthcare: A Study. Journal of Multimedia Technology & Recent Advancements. 2025; 12(01):23-29.

[149]. Jatin M. Patil, "Robotic Surgery using AI-Driven-IoT Based Decision Making for Safety: A Study" *International Journal of Artificial Intelligence of Things (AIoT) in Communication Industry*, vol. 1, no. 1, pp. 35-44, Mar. 2025.

[150]. K. K. S. Liyakat,(2025). VHDL Programming for Secure True Random Number Generators in IoT Security, Research & Review: Electronics and Communication Engineering, vol. 2, no. 1, pp. 38-47, Mar. 2025.

[151]. Kazi Kutubuddin Sayyad Liyakat. E-Comers and AI: Product Recommendation and Pricing. *Journal of Artificial Intelligence Research & Advances.* 2025; 12(2): 44–52p.

[152]. Jatin M Patil, Velapure Amol S, and Khadake Suhas B. The Intersection of Nanotechnology and IoT: New Era of Connectivity. *International Journal of Applied Nanotechnology*. 2025; 11(01): 9-17p.

[153]. KKS Liyakat, (2025). Nanorobotics in Cancer Treatment: A Study. *International Journal of Nanomaterials and Nanostructures.* 2025; 11(1): 44-52p. Available from:https://journalspub.com/publication/ijnn/article=16043

[154]. KKS Liyakat. (2025). Nanomaterial and e-Skin Technology: A Study. International Journal of Nanobiotechnology. 2025; 11(1): 10–16p.

[155]. N. R. Mulla and K. K. S. Liyakat, (2025). Pipeline Pressure and Flow Rate Monitoring Using IoT Sensors and ML Algorithms to Detect Leakages, *Int. J. Artif. Intell. Mech. Eng*., vol. 1, no. 1, pp. 20–30, Jun. 2025.

[156]. Nikat Rajak Mulla, (2025). Sensor-based Aircraft Wings Design Using Airflow Analysis, *International Journal of Image Processing and Smart Sensors,* vol. 1, no. 1, pp. 55-65, Jun. 2025.

[157]. N. R. Mulla and K. K. S. Liyakat, (2025). A Study on Machine Learning for Metal Processing: A New Future, *International Journal of Machine Design and Technology,* vol. 1, no. 1, pp. 56–69, Jun. 2025.

[158]. N. R. Mulla, and K. K. S. Liyakat, "Node MCU and IoT Centered Smart Logistics," *International Journal of Emerging IoT Technologies in Smart Electronics and Communication,* vol. 1, no. 1, pp. 20-36, Jun-2025.

[159]. Renuka Dnyanoba Todakar, Jadhav Vaibhavi Kishor. (2025). Kinetic Power Gyms for Revolutionizing Fitness. *Journal of Telecommunication, Switching Systems and Networks*. 2025; 12(02):13-21. Available from: https://journals.stmjournals.com/jotssn/article=2025/view=214971

[160]. Kazi Kutubuddin Sayyad Liyakat. Cardiovascular Modeling with Computational and Mathematical Methods. *Research & Reviews: A Journal of Bioinformatics*. 2025; 12(2): 1–11p.

[161]. Nikat Rajak Mulla, Kazi Kutubuddin Sayyad Liyakat. Air Flow Analysis in Sensor-Based Aircraft Wings Design. *Recent Trends in Fluid Mechanics*. 2025; 12(2): 29– 39p.

[162]. Nikat Rajak Mulla, Kazi Kutubuddin Sayyad Liyakat. IoT Sensors To Monitor Pipeline Pressure and Flow Rate Combined with Ml-Algorithms to Detect Leakages. *Recent Trends in Fluid Mechanics.* 2025; 12(2): 40–48p.

[163]. Heena Rafiq Shaik, Kazi Kutubuddin Sayyad Liyakat. Juncture of Nanotechnology and IoT: Novel Era of Connectivity. *Nano Trends – A Journal of Nano Technology & Its Applications.* 2025; 27(03):-. Available from: https://journals.stmjournals.com/nts/article=2025/view=212921

[164]. Kazi Kutubuddin Sayyad Liyakat. Machine Learning Revolutionizing Server Management and Performance. Journal of Computer Technology & Applications. 2025; 16(02):-. Available from: https://journals.stmjournals.com/jocta/article=2025/view=0

[165]. Kazi Kutubuddin Sayyad Liyakat. KVS Approach for IoT Network Security: A Novel Approach to IoT Network Security With B-Cell Inspired Models. Journal of Network security. 2025; 13(02):16-25. Available from: https://journals.stmjournals.com/jons/article=2025/view=207920

[166]. Dr. Kazi Kutubuddin Sayyad Liyakat. Nanotechnology: Effective Pesticide Solutions for Jawar Leaf Diseases. Journal of Nanoscience, NanoEngineering & Applications. 2025; 15(02):-. Available from: https://journals.stmjournals.com/jonsnea/article=2025/view=204242

[167]. Parkhe Suyash Swaminath, Dhyavarkonda Udaykiran Tulshidas, Todkar Renuka Dnyanoba, Pawar Radhika Maruti, Kazi Kutubuddin Sayyad Liyakat. Nanotechnology in Internet of Things: A Powerful Partnership Shaping the Future. Journal of Nanoscience, NanoEngineering & Applications. 2025; 15(02):-. Available from: https://journals.stmjournals.com/jonsnea/article=2025/view=211534

[168]. Nikat Rajak Mulla, Kazi Kutubuddin Sayyad Liyakat. Nano-Materials in Vaccine Formation and Chemical Formulae's for Vaccination. Journal of Nanoscience, NanoEngineering & Applications. 2025; 15(03):-. Available from: https://journals.stmjournals.com/jonsnea/article=2025/view=216526

[169]. A K. Mulani, H. T. Shaikh, and K. K. S. Liyakat, (2025). Nuclear Power Generation Using UO2 Materials, *Journal of Advance Electrical Engineering and Devices,* Vol. 3, No. 2, pp. 27-40, Jul. 2025.

[170]. H. T. Shaikh and K. K. S. Liyakat, "Empowering the IoT: The Study on Role of Wireless Charging Technologies," Journal of Control and Instrumentation Engineering, vol. 11, no. 2, pp. 29-39, Jul. 2025.

[171]. H. T. Shaikh, and K. K. S. Liyakat, "Pre-Detection Systems Transfiguring Intoxication and Smoking Using Sensor and AI," Journal of Instrumentation and Innovation Sciences, vol. 10, no. 2, pp. 19-31, Jul. 2025.

[172]. Vaishnavi Ashok Desai, (2025). AI and Sensor Systems Revolutionizing Intoxication and Smoking Pre-Detection. *Journal of Control & Instrumentation*. 2025; 16(3): 15–26p.

[173]. Heena Tajoddin Shaikh. (2025). The Future of Coastal Resilience: Harnessing Satellite Technology. *Advance Research in Communication Engineering and Its Innovations*, 28–36. Retrieved from https://matjournals.net/engineering/index.php/ARCEI/article/view/2281

[174]. H. T. Shaikh and K. K. S. Liyakat., (2025). Sensor- based Intelligent Wearable Glasses, *Journal of Digital Circuitry Innovations in Electrical Devices,* vol. 1, no. 2, pp. 16-24, Jul. 2025.

[175]. Kazi Kutubuddin Sayyad Liyakat. Nanorobots: The Fight against Cholesterol. Nano Trends – A Journal of Nano Technology & Its Applications. 2025; 27(02). Available from: https://journals.stmjournals.com/nts/article=2025/view=205244

[176]. H. T. Shaikh and K. K. S. Liyakat, "Millimetre Wave: A Study on the Backbone of Future IoT Connectivity", *Advance Research in Analog and Digital Communications*, Vol. 2, no. 2, pp. 20-31, Aug. 2025.

[177]. Ayesha Khalil Mulani. Microwave Signals: A New Frontier in Non-Invasive Medical Diagnostics: A Study. Journal of Microwave Engineering & Technologies. 2025; 12(3): 27–41p.

[178]. Ayesha Khalil Mulani. Revolutionizing Optical Fibre Field Distribution with Linear Finite Element Method. Trends in Opto-electro & Optical Communication. 2025; 15(3): 31-41p.

[179]. H. T. Shaikh and K. K. S. Liyakat, (2025). Robust Access Control Mechanisms in IoT Security using VHDL Programming, Journal of VLSI Design and Signal Processing, vol. 11, no. 2, pp. 31-40, Aug. 2025. Available at: https://matjournals.net/engineering/index.php/JOVDSP/article/view/2351

[180]. Radhika Maruti Pawar, Kulkarni Amarja Bhaskar, Patu Shradha Gangadhar, Sensors and Artificial Intelligence based Intelligent Thermos. Recent Trends in Sensor Research & Technology. 2025; 12(3): 37–45p.

[181]. Ayesha Khalil Mulani. Optical Fibre Pressure Sensor in Medicine: A Study. Recent Trends in Sensor Research & Technology. 2025; 12(3): 18–27p.

[182]. Vaishnavi Ashok Desai, Heena Tajoddin Shaikh, Sensor and AI Based Pre- Detection Systems Transfiguring Intoxication & Smoking. Journal of Telecommunication, Switching Systems and Networks. 2025; 12(3): 37–50p.

[183]. C. M. Abhangrao and K. K. S. Liyakat, "A study on hybrid intelligence in COBOT," Journal of Mechanical Robotics, vol. 10, no. 2, pp. 15–29, Sep. 2025.

[184]. Heena Tajoddin Shaikh, (2025). The Future of Cancer Management: A Guide to Nanosensor Applications. *Recent Trends in Semiconductor and Sensor Technology*, 1–10.

[185]. Heena T Shaikh. A Study on Automatic Feedback Control by Image Processing for Mixing Solutions in a Microfluidic Device. International Journal of Advanced Control and System Engineering. 2025; 3(2): 32–41p.

[186]. Heena T Shaikh. A Study on Unmanned Air Vehicles (UAV). Journal of Aerospace Engineering & Technology. 2025; 15(3): 14–27p.

[187]. Nikat Rajak Mulla. Nanomaterials in Vaccine Formation and Chemical Formulae for Vaccination. Journal of Nanoscience, Nanoengineering & Applications. 2025; 15(3): 1–12p.

[188]. K. K. S. Liyakat, "Waste-to-Energy (WtE) Plants: A Study," Journal of Alternative and Renewable Energy Sources, vol. 11, no. 3, pp. 1-15, Oct. 2025.

[189]. Sultanabanu Sayyad Liyakat. (2024). Advancing IoT Connectivity through Very Large-Scale Integration of Semiconductor Technology. Journal of Semiconductor Devices and Circuits. 2024; 11(03):54-63. Available at: https://journals.stmjournals.com/josdc/article=2024/view=190467/

[190]. Dr. Kazi Kutubuddin Sayyad Liyakat. Sensor and IoT centered Smart Agriculture by NodeMCU. Recent Trends in Sensor Research & Technology. 2024; 11(03): 24-32. Available from: https://journals.stmjournals.com/rtsrt/article=2024/view=0

[191]. Dr. Kazi Kutubuddin Sayyad Liyakat. KSK Approach to Smart Agriculture: Utilizing AI-Driven Internet of Things (AI IoT). Journal of Microcontroller Engineering and Applications. 2024; 11(03): 41-50. Available from: https://journals.stmjournals.com/jomea/article=2024/view=0

[192]. Pathan Muskan Ibrahim.(2025). Photochemical Materials for Light-Responsive Optical Switching: AI-Optimized Design of Dynamic Visual Effects. International Journal of Photochemistry and Photochemical Research, Volume 3, Issue 2. 2025; 3(2): 13–27p.

[193]. Shaikh A. Hakim A. Razzaque. (2025). A Study on AI-Enhanced Environmental Toxicology: Sensor-Driven Predictive Framework. Research & Reviews: A Journal of Toxicology. 2025; 15(3): 1–20p.

[194]. Paul Pranit Sunil, Dhyvarkonda Udaykiran Tulshidas, Gone Yashasvi Prakash. (2025). AI-Powered Motorcycle Anti-Theft and Safety System, International Journal of Advanced Research in Science, Communication and Technology, Volume 5, Issue 1, October 2025. pp. 445- 454.

[195]. P. M. Ibrahim and K. K. S. Liyakat, "Guardian Angel: An Innovative Mobile Application for Rapid Accident Notification and Emergency Response," *Advance Research in Analog and Digital Communications*, vol. 2, no. 3, pp. 7-20, Oct. 2025.

[196]. Muskan Ibrahim, Shaikh A. Hakim A. Razzaque, Heena T Shaikh, Kazi. (2025). VHDL-Based Strategies for Protecting IoT Devices from Power and Electromagnetic Side-Channel Attacks: A Study. *Recent Trends in Electronics & Communication Systems*. 2025; 12(3): 30–40p. Available at: https://journals.stmjournals.com/article/article=2025/view=234151/

[197]. Amar Parmeshwar Bansode, (2025). Electronics and Communication Design of an AI-Powered Smart Chair for Real-Time Multilingual Interaction. *Recent Trends in Electronics & Communication Systems*. 2025; 12(3): 16–29p.

[198]. Pathan Muskan Ibrahim, Shaikh A. Hakim A. Razzaque, Heena T Shaikh, Kazi Kutubuddin Sayyad Liyakat. (2025). Reimagining Nuclear Reactor Safety: The Study toward Passive Safety. *Journal of Nuclear Engineering & Technology*. 2025; 15(3): 6–15p.

[199]. Ayesha Khalil Mulani, Heena Tajuddin Shaikh. (2025). Nuclear Reactor Safety Using Fuel Pallet: A Study. *Journal of Nuclear Engineering & Technology*. 2025; 15(3): 16–23p