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Cost Accounting

A Textbook for B.Com., Semester IV

Dr. Shruti Gupta • Dr. Reeta
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ISBN: 978-81-949469-7-7

First Edition 2021

Printed at: Narain Printers, Noida

As per
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COST ACCOUNTING

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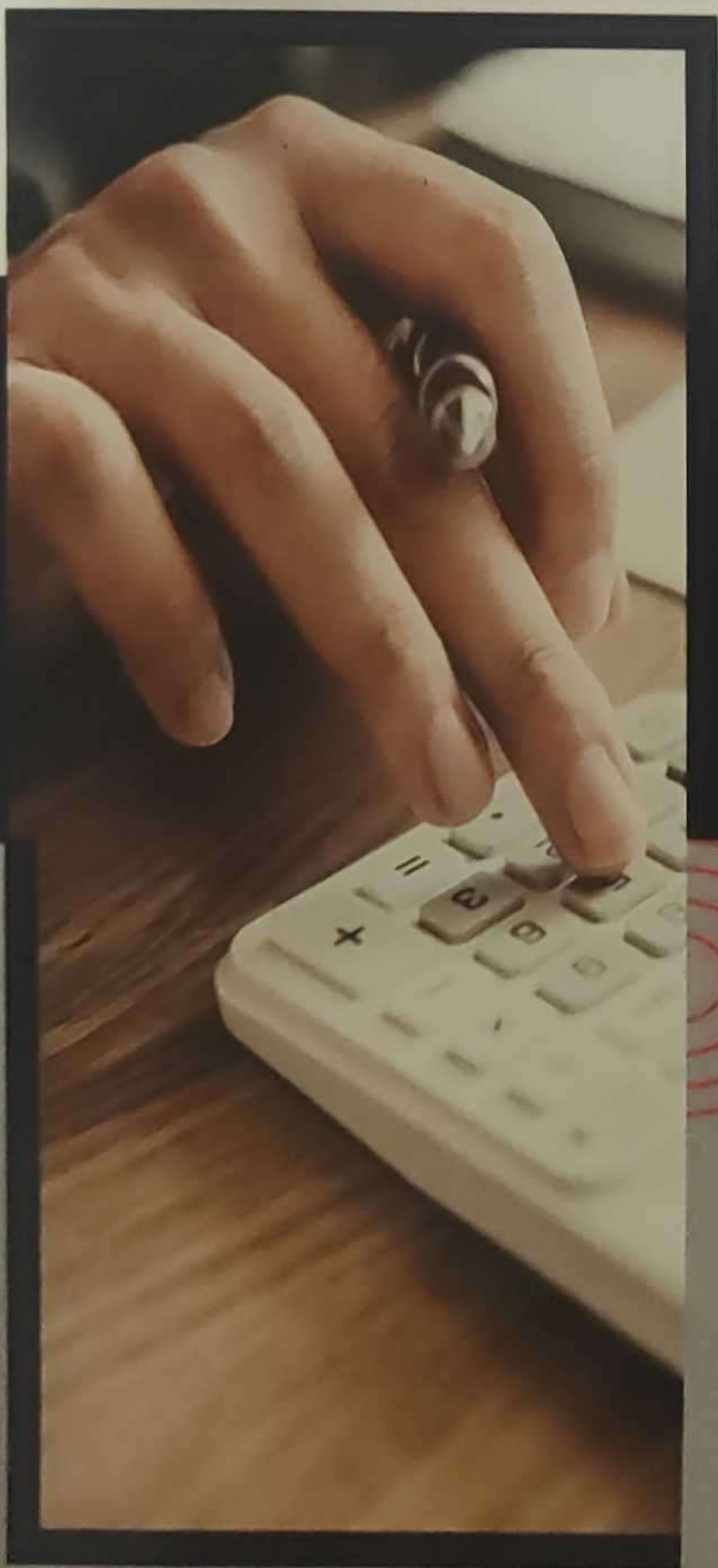

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ISBN: 978-81-949469-9-1

First Edition 2021

Printed at: Narain Printers, Noida

frontiers in Microbiology

REVIEW
published: 28 January 2021
doi: 10.3389/fmicb.2020.619766

Chemical-Assisted Microbially Mediated Chromium (Cr) (VI) Reduction Under the Influence of Various Electron Donors, Redox Mediators, and Other Additives: An Outlook on Enhanced Cr(VI) Removal

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Edited by:
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Specialty section:
This article was submitted to Microbiotechnology, a section of the journal Frontiers in Microbiology

Received: *21 October 2020*
Accepted: *16 December 2020*
Published: *28 January 2021*

Citation:
Rahman Z and Thomas L (2021) Chemical-Assisted Microbially Mediated Chromium (Cr) (VI) Reduction Under the Influence of Various Electron Donors, Redox Mediators, and Other Additives: An Outlook on Enhanced Cr(VI) Removal. Front. Microbiol. 11:619766. doi: 10.3389/fmicb.2020.619766

Chromium (Cr) (VI) is a well-known toxin to all types of biological organisms. Over the past few decades, many investigators have employed numerous bioprocesses to neutralize the toxic effects of Cr(VI). One of the main process for its treatment is bioreduction into Cr(III). Key to this process is the ability of microbial enzymes, which facilitate the transfer of electrons into the high valence state of the metal that acts as an electron acceptor. Many underlying previous efforts have stressed on the use of different external organic and inorganic substances as electron donors to promote Cr(VI) reduction process by different microorganisms. The use of various redox mediators enabled electron transport facility for extracellular Cr(VI) reduction and accelerated the reaction. Also, many chemicals have employed diverse roles to improve the Cr(VI) reduction process in different microorganisms. The application of aforementioned materials at the contaminated systems has offered a variety of influence on Cr(VI) bioremediation by altering microbial community structures and functions and redox environment. The collective insights suggest that the knowledge of appropriate implementation of suitable nutrients can strongly inspire the Cr(VI) reduction rate and efficiency. However, a comprehensive information on such substances and their roles and biochemical pathways in different microorganisms remains elusive. In this regard, our review sheds light on the contributions of various chemicals as electron donors, redox mediators, cofactors, etc., on microbial Cr(VI) reduction for enhanced treatment practices.

Keywords: Cr(VI) reduction, chemical-assisted, electron donors, electron mediators, microbially mediated process

INTRODUCTION

Chromium (Cr) is a pervasive toxin that inhabits almost every component of the environment including aerial, terrestrial, aquatic, and biological systems (Rahman and Singh, 2019). The nearly ubiquitous existence of this element is detrimental to natural establishments of Earth. Various environment and health protection agencies have considered Cr as a priority pollutant

(DesMarias and Costa, 2019; Laxmi and Kaushik, 2020). The high magnitude of Cr contamination across the globe is estimated to pour risk on approximately 16 million people (Pure Earth, 2015). Both anthropogenic and natural events can contribute to the global Cr reservoir (Jeřábková et al., 2018; Coetzee et al., 2020; Tumolo et al., 2020). For example, industrial activities such as discharge of effluents and solid wastes from industrial energy production, manufacturing of refractories, stainless steel and chemical dye pigment production, chrome plating, treatment of wood, use of organic fertilizers and chemicals, waste and wastewater management, tanning, mining, etc., have created a widespread accumulation of Cr in their surroundings (Barnhart, 1997; Wilbur et al., 2012; Huang et al., 2019; Rahman and Singh, 2019). Cr is also used as catalyst, oxidizing agent and cooling agent with water (Saha et al., 2013). In another way, hastened dissolution of chromite and other minerals from natural reserves (i.e., serpentine soil and ultramafic rocks) as a natural event instigates the release of Cr into groundwaters upon suitable conditions (Gonzalez et al., 2005; Islam et al., 2020). Moreover, volcanic eruptions and forest fires also account for some Cr contamination in the environment (Viti et al., 2014).

The toxicity of Cr relies upon its oxidation states. Among commonly occurring states of Cr(0), Cr(III), and Cr(VI), the last species is viewed as more toxic than any other species (RoyChowdhury et al., 2018; Pechancová et al., 2019). Cr(VI) usually exists in the form of oxyanions of $HCrO_4^-$, CrO_4^{2-}, or $Cr_2O_7^{2-}$ after reacting with oxygen (Rahman and Singh, 2019). The bioavailability and mobility of Cr(VI) are highly dependent on pH regulation, molecular oxygen (O_2) availability, and the presence of organic matter and manganese oxides (MnO_2) (Reijonen and Hartikainen, 2016; Shahid et al., 2017; Choppala et al., 2018). Cr speciation is also sensitive to soil redox potential (Eh), as the reduction and oxidation processes prevail at low and high Eh values, respectively (Xiao et al., 2015). Cr(VI) compounds are more toxic than Cr(III) compounds because of their high water solubility and mobility, whereas Cr(III) forms precipitation at body pH and does not exist in mobile species. Because of the structural similarity of chromate with sulfate, Cr(VI) can pass the cell membrane, but trivalent Cr fails to do so (Mukherjee et al., 2013). Further, the high oxidizing potential of Cr(VI) is also liable for its toxic effects in biological organisms (Sobol and Schiestl, 2012).

Cr(VI) displays genotoxic, carcinogenic, teratogenic, and mutagenic effects along with epigenetic profile silencing (Hu et al., 2016; DesMarias and Costa, 2019; Rager et al., 2019). As per the United States Environmental Protection Agency (US EPA), Cr(VI) is categorized as a "Group A" human carcinogen by the inhalation route of exposure (US EPA, 1998). Cr can induce phytotoxicity in plants by interfering with nutrient uptake and photosynthesis, generation of reactive oxygen species (ROS), lipid peroxidation, and altering the antioxidant activities (Shahid et al., 2017). Even elevated Cr(VI) concentrations can reduce the abundance of microbial communities by electron competing ability, inhibition of extracellular polymeric substances (EPSs) synthesis, and other effects including overproduction of ROS, protein and enzyme dysfunction, destruction of thiol and iron-sulfide cluster, inhibition of functional genes, nutrient assimilation and metabolic pathways, lipid peroxidation, DNA damage, etc. (Bhakta, 2017; Liu et al., 2017; Sun et al., 2019).

Removal of Cr(VI) from the environment is challenging. There are many methods such as ion exchange, electrochemical precipitation, solvent extraction, membrane separation, evaporation, foam separation, ultrafiltration, electrodialysis, cementation, biosorption, and reduction (Mukherjee et al., 2013). However, the conventional reduction and precipitation methods of Cr(VI) removal utilize large amounts of chemicals and generate enormous toxic sludge (Mukherjee et al., 2013). The recent possible removal measures rely on the implementation of biotechnological approaches, considering ecofriendly and cost-effective approaches (Fernández et al., 2018; Jobby et al., 2018). Especially, Cr(VI) reduction by microorganisms is being recognized as an eventual treatment. Despite successful outcomes, certain disadvantages such as low efficiency and poor compatibility due to limited availability of electron donors and other inducers often hamper the prominence of Cr(VI) bioremediation in large-scale implementation (Malaviya and Singh, 2016; Beretta et al., 2019; Wang et al., 2020). These limitations can be subdued by introducing low concentrations of suitable chemicals in the medium (**Figure 1**). But such chemical integration demands a detailed understanding of additive-influenced mechanisms in credible microorganisms. Considering this significance, this review recognizes and emphasizes the experimental studies of influences of electron donors, electron mediators, and other chemical additives on microbial Cr(VI) reduction for the enhanced Cr(VI) removal approaches.

Cr(VI) REDUCTION BY MICROORGANISMS

Several different microorganisms have adopted various strategies to counter-effect the toxicity of Cr(VI). Among different methods, enzymatic reduction of Cr(VI) into Cr(III) by microorganisms is the best characterized mechanism for its bioremediation (Singh et al., 2008). All Cr(VI)-resistant microbes cannot reduce Cr(VI). However, Cr(VI) resistance is a common phenomenon in all Cr(VI) bioreducers, which delivers proficiency in detoxification process (Singh et al., 2008; Thatoi et al., 2014). The catalysis of Cr(VI) reduction can be demonstrated using chromosome or plasmid-encoded non-specific enzymes (Cervantes and Campos-García, 2007; Pradhan et al., 2016; Baldiris et al., 2018). These enzymes are mainly oxidoreductases such as chromate reductases (ChrA and YieF), NADH-dependent nitroreductase, iron reductase, quinone reductases, hydrogenases, NADH/NADPH-dependent flavin reductases, and NADPH-dependent reductases (Puzon et al., 2002; Kwak et al., 2003; Ackerley et al., 2004). Even many microorganisms exhibited Cr(VI) reduction using reductases with multiple substrate specificity (**Table 1**). Cr(VI) reduction enzymes have shown inductive or constitutive expression in different microorganisms (Ibrahim et al., 2012; Chai et al., 2018).

Biological Cr(VI) reduction activities can occur at extracellular, cell membrane, and intracellular locations in

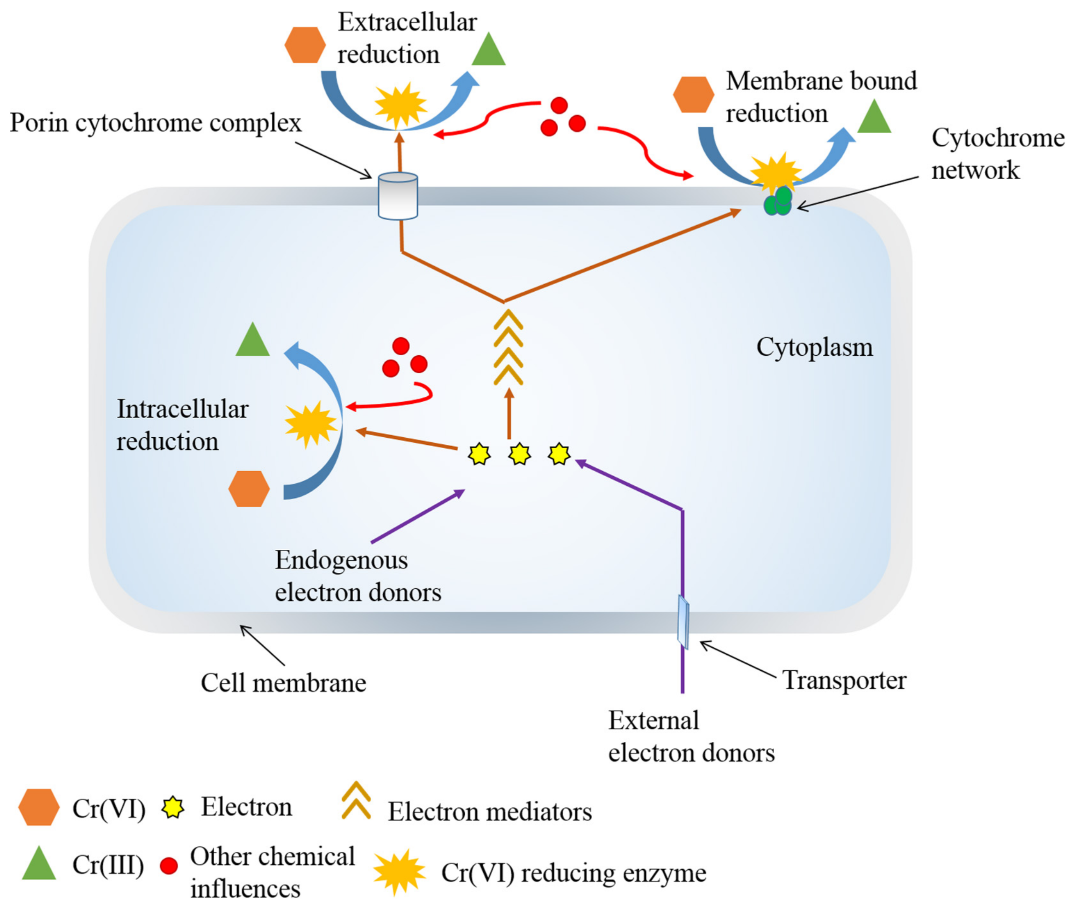

FIGURE 1 | Role of various chemicals other than electron donors and mediators on enhanced Cr(VI) reduction.

TABLE 1 | Cr(VI) reduction in different microorganisms using reductases with multiple substrate specificity.

Microorganisms	Enzymes	Other substrates	References
Alishewanella sp. WH16-1	Selenite reductase (CsrF)	Selenium (Se)	Xia et al. (2018)
Leucobacter sp.	Dihydrolipoyl dehydrogenase	Dihydrolipoamide	Sarangi and Krishnan (2016)
Caldicellulosiruptor saccharolyticus	Ni-Fe hydrogenase	Hydrogen	Bai et al. (2018)
Vibrio harveyi	Nitroreductase (NfsA)	Nitroaromatic compounds	Kwak et al. (2003)
Staphylococcus aureus LZ-01	NfoR	Flavin and FMN	O'Neill et al. (2020)
Escherichia coli	NemA	Glycerol trinitrate and pentaerythritol tetranitrate	Robins et al. (2013)
Streptomyces violaceoruber strain LZ-26-1	Thioredoxin operon	Thioredoxin	Chen et al. (2014)

aerobic and anaerobic conditions (Cervantes et al., 2001; Cervantes and Campos-García, 2007). Extracellular Cr(VI) reduction is regulated by soluble (cytoplasmic) proteins exported to the extracellular medium by an energy-intensive process (Cheung and Gu, 2007; Elangovan et al., 2010; Das et al., 2014). This mechanism is accustomed to protect microbes from the damaging effects of Cr(VI) by minimizing its active intracellular transport (Wani et al., 2018). In anaerobic reduction, microorganisms may use Cr(VI) as the terminal electron acceptor in electron transport system associated with membrane enclosed regions (Ramírez-Díaz et al., 2008). Consecutively, the transformation of Cr(VI) into Cr(III) can also occur spontaneously in microorganisms by chemical reactions using different intracellular or extracellular compounds, metabolic end products, and intracellular reductants of ascorbate glutathione, cysteine, and hydrogen peroxide (H_2O_2) (Donati et al., 2003; Viti and Giovannetti, 2007; Poljsak et al., 2010; Thatheyus and Ramya, 2016).

The enzymatic reduction of Cr(VI) to Cr(III) can also yield variable concentrations of ROS, which may or may not involve in the formation of reactive intermediates (Cheng et al., 2009; McNeill et al., 2012; Baldiris et al., 2018). However, different

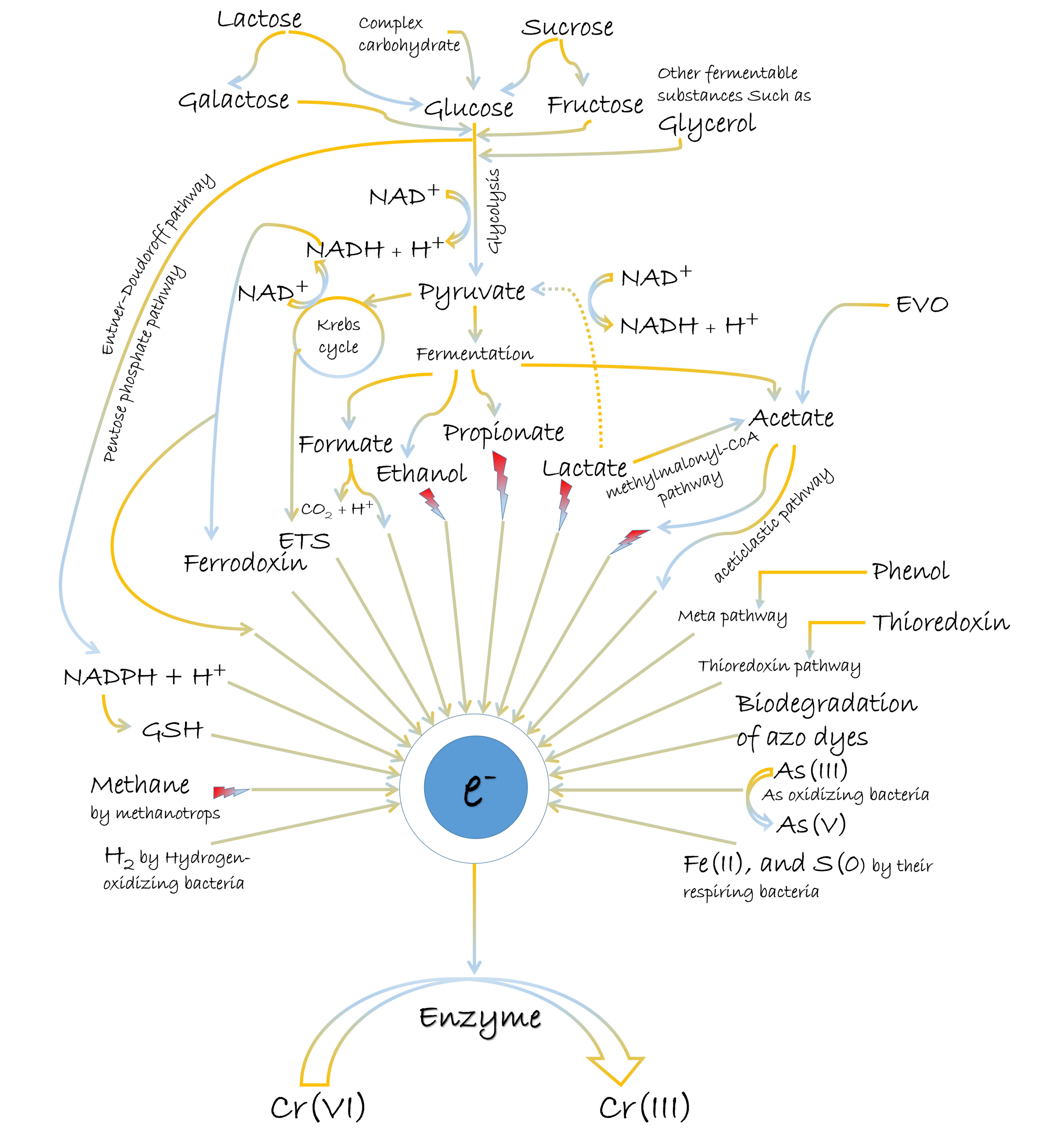

FIGURE 2 | The general mechanisms of chemical-assisted microbially mediated Cr(VI) reduction.

reductase enzymatic activities possess some capacity to alleviate the effects of ROS. Accordingly, homologous enzymes involved in catalyzing the electron movement from electron donors to reduce Cr(VI) are classified into class I (tight) and class II (semitight) reductases (Thatoi et al., 2014; Baldiris et al., 2018). The class I reductases catalyze one-step electron reduction of Cr(VI) to form the highly unstable Cr(V) intermediate. The tendency of this reactive intermediate to oxidize into Cr(VI) by donating electrons to molecular oxygen generates ample ROS. However, class II chromate reductases are two electron reducers of Cr(VI), in which the formation of Cr(III) proceeds without forming a Cr(V) intermediate. This results in much lesser generation of ROS during the reduction process (Thatoi et al., 2014). Moreover, quinone reductase activity can further neutralize the effects of ROS to some extents (Cheung and Gu, 2007; Thatoi et al., 2014). Apart from this, chromate-resistant microorganisms also tend to stimulate the efflux system, SOS response of DNA damage repair, ROS scavenging enzymes (catalase, superoxide dismutase, etc.), and non-enzymatic antioxidants (vitamin C and E, carotenoids, thiol antioxidants, and flavonoids) for inactivating ROS-mediated oxidative stress (Ackerley et al., 2006; Cervantes and Campos-García, 2007; Flora, 2009).

ELECTRON DONORS

In general, electron donors release electrons during cellular respiration accompanied by the release of energy. But such cellular reaction in microorganisms also enables biological treatment by providing electrons to Cr(VI) (Ceci et al., 2019; Truskewycz et al., 2019). Even suitable electron donors can facilitate the enhancement of reduction activity (Poopal and Laxman, 2009; Alam and Ahmad, 2012; Ibrahim et al., 2012; Shi et al., 2012). The requirement of electron donor is indispensable for both microbial growth and Cr(VI) reduction (Poopal and Laxman, 2009). Most microbial species capable of Cr(VI) reduction are heterotrophic and need such additional nutrition from external sources during the reduction process (Ancona et al., 2020). Certainly, some endogenous reserves can also serve electrons to Cr(VI) during its bioreduction (McLean and Beveridge, 2001; Ray et al., 2018).

The most common electron donors for Cr(VI) reduction are organic molecules, although reports on inorganic matters as reducing equivalents also exist (**Figure 2**). Usually, the abundant oxygen-containing functional groups (C–O, CO–OH, C–OH, and C–O–R) in organic matters present the utility as electron donors (π electrons) (Choppala et al., 2016; Shaheen et al., 2019; Xu et al., 2019). Glucose, fructose, lactose, pyruvate, lactate, citrate, glycerol, acetate, formate, NADH/NADPH, reduced glutathione, etc., are the various popular electron donors for Cr(VI) reduction (Garbisu et al., 1998; Poopal and Laxman, 2009; Murugavelh and Mohanty, 2013; Salamanca et al., 2013; Ahemad, 2014; Mala et al., 2015). Many such examples for the treatment of Cr(VI) can be further studied from **Table 2**. Among them, the widespread electron donor implicated in Cr(VI) reduction process is NAD(P)H, which is usually associated with intracellular reduction (Robins et al., 2013; Tan et al., 2020). Even many chromate reductase enzymes exhibited NAD(P)H-dependent properties, where the attachment of dehydrogenase molecule to enzyme is crucial for a feasible reaction. The reductase enzyme in *Alishewanella* sp. possessed Arg^{13} and Gly^{113} residues for the cobinding of NAD(P)H and Cr(VI) (Xia et al., 2018). Another Flavin mononucleotide (FMN)-containing chromate reductase of *Gluconacetobacter hansenii* (Gh-ChrR) induced structural rearrangement of active site during the binding of chromate anion and NADH. With this rearrangement, both species could bind simultaneously for efficient enzyme cycling, of which binding site otherwise overlapped with the electron donor (Jin et al., 2012). Also, microbial Cr(VI) reduction using glucose as the donor source is very prominent (Camargo et al., 2003; Megharaj et al., 2003; Satarupa and Paul, 2013; Ziagova et al., 2014). Glucose, being the most easily metabolized carbon source, can deliver maximum electrons for Cr(VI) reduction. The synthesis of volatile fatty acids (VFAs) during glucose fermentation provides additional sources of electron donors, which can also be attributed for the improved performance of Cr(VI) reduction (Zheng et al., 2019). Furthermore, glucose exhibits indirect action on Cr(VI) reduction by promoting microbial growth (Leita et al., 2011). However, the role of glucose as the most suitable electron donor is not consistent for all Cr(VI) reducer. Anaerobic process by *Pannonibacter phragmitetus* LSSE-09 promoted Cr(VI) reduction more in presence of acetate, lactate, and pyruvate rather than glucose (Xu et al., 2011). Another anaerobic strain, *P. phragmitetus* BB also exhibited more reduction of Cr(VI) in presence of lactate than many other electron donors. Metabolic analyses of strain BB elucidated that the presence of Cr(VI) upregulated pyruvate dehydrogenase and lactate dehydrogenase, and these dehydrogenases preferentially transferred the cellular electrons to extracellular Cr(VI) over other electron acceptors (Chai et al., 2019). In another study, anaerobic suspensions of *Pelosinus* sp. HCF1 reduced chromate in the presence of lactate as a sole electron donor (Beller et al., 2013). Lactate fermentation to acetate and propionate through methylmalonyl-CoA pathway also broadened the availability of electron donors in the system (Beller et al., 2013). Bill et al. (2019) also corroborated the evidence of lactate fermentation into simpler metabolites and further degradation into CO_2. In this process, Cr(VI) removal was basically associated with the breakdown of carboxylic acids. However, lactate as an electron donor also causes a significant abiotic Cr(VI) reduction due to the formation of a lactate–Cr(VI) complex or sodium lactate syrup that functions as a non-specific reductant (Brodie et al., 2011). Fungal metabolites such as salicylate, tartrate, and citrate produced by a metalliferous *Aspergillus tubingensis* Ed8 were also stimulators for Cr(VI) reduction (Coreño-Alonso et al., 2009). However, non-fermentable substrates such as citrate, butyrate, and acetate as electron donors have shown usually lower effects for enhanced Cr(VI) removal rates (Orozco et al., 2010). Nevertheless, the contribution of acetate as the most suitable electron donor for Cr(VI) reduction in certain microorganisms is also not deniable. The accumulation of acetate as one of the fermentation product has greatly influenced Cr(VI) reduction in the anaerobic system (Bai et al., 2018; Zheng et al., 2019; Zhang et al., 2020). In an investigation, addition of Cr(VI) shifted the amounts of fermentation products toward more oxidative form, i.e., acetate (∼2.5 times) (Sharma, 2002). The plausible reason of this shift toward acetate formation after Cr(VI) exposure is likely to secure more NADH molecule that can be channeled toward bioreduction process. Mass balance reaction also supported the reason, which derived more loss of NADH molecules by butyrate and lactate formation than acetate synthesis (Sharma, 2002). Occasionally, acetoclastic pathway by Archaea instigated the release of electrons from acetate for Cr(VI) reduction (Hu et al., 2018). Aerobic bacterial strains, *Lysinibacillus fusiformis* ZC1 and *Intrasporangium* sp. strain Q5-1 also consumed acetate as the most suitable electron donor for Cr(VI) reduction in reports of He et al. (2011) and Yang et al. (2009), respectively.

TABLE 2 | Enhancement of Cr(VI) reduction using different electron donors by different microorganisms.

Microorganisms	Electron donors	Aerobic/anaerobic	Concentrations of electron donor (a) and Cr(VI) (b)	Chromium reduction (%)		References
				Without electron donor	With electron donor	
Halomonas chromatireducens AGD 8–3	Acetate	Aerobic	(a) 20 mM (b) 30 mg/L	0	>90	Shapovalova et al., 2009
Halomonas smyrnensis KS802	Galactose	Aerobic	(a) 4% (b) 2 mM	82.5	100	Biswas et al., 2018
Bacillus methylotrophicus	Reduced glutathione	Aerobic	(a) 20 mM (b) 200 μM	89.8	94.5	Mala et al., 2015
Ochrobactrum intermedium Rb-2	Gluconate	Aerobic	(a) 1% (b) 1,000 mg/L	<95	99	Batool et al., 2012
Enterobacter sp. DU17	Glucose fructose	Aerobic	0.2% 100 mg/L	59	100 100	Rahman and Singh, 2014
Pseudomonas aeruginosa CRM100	Citrate glycerol	Anaerobic	(a) 4.0 g/L (b) 100 mg	0	99.73 88.4	Salamanca et al., 2013
Pelosinus sp. HCF1	Lactate	Anaerobic	(a) 20 mM (b) 45 μM	<12	>90	Beller et al., 2013
Arthrobacter sp. LLW01	Lactate	Aerobic	15 mM 50 μM	0	80	Field et al., 2018
Microbial consortium	H_2: CH_4	Anaerobic	1:1 ratio 10 mg/L Cr(VI)	0	95.5	He et al., 2020
Flexivirga alba ST13T	Molasses	Aerobic	0.4% 0.5–0.6 mg/L	<10	>95	Ikegami et al., 2020
Stenotrophomonas sp. WY601	Lactose, fructose, and glucose	Anaerobic	2% 2,500 mg/L	0	68–80	Liu et al., 2019a
Bacillus sp. M6	Glycerol	Aerobic	0.1 mM/L 20 mg/L	3.4	69.2	Li et al., 2019a
Microcosms	Yeast extract	Aerobic	200 mg/L 1,000 μg/L	<10	100	Ancona et al., 2020
Bacillus sp. CRB-B1	Fructose	Aerobic	10 g/L 100 mg/L	0	89.54	Tan et al., 2020
Bacillus cereus	NADH, NADPH	Aerobic	1 g/L 60 mg/L	40	91.52, 96.54	Murugavelh and Mohanty, 2013
Lysinibacillus fusiformis ZC1	Acetate, NADH	Aerobic	1% 0.1 mM	21	92.4 92.0	He et al., 2011
Intrasporangium sp. Q5–1	Acetate	Aerobic	0.5 mM/L 0.2 mM	75	95	Yang et al., 2009
Oceanobacillus oncorhynchi W4	Glycerol	Aerobic	3 g/L 10 mg/L	<10	72.3	Zheng et al., 2019

The bacterium *Pseudomonas aeruginosa* CCTCC AB91095 offered simultaneous removal of phenol and Cr(VI), where the degradation of the former compound supported Cr(VI) reduction (Song et al., 2009). Supposedly, meta-pathways maintained the requirement of electrons from phenol biodegradation for Cr(VI) removal (Chen et al., 2003; Song et al., 2009). The bacterium, *Brevibacterium casei* employed azo dye acid orange 7 (AO7) as an electron donor for Cr(VI) reduction by coupling with dye decolorization under nutrient-limiting conditions (Ng et al., 2010). Another reactive black-5 azo dye was also proposed to serve electron for Cr(VI) reduction by bacterial strains (Mahmood et al., 2013). Chen et al. (2014) identified a new pathway for Cr(VI) reduction by *Streptomyces violaceoruber* LZ-26-1, which involved thioredoxin as an electron donor following its reduction using thioredoxin reductase. However, the main supply of electrons to thioredoxin was originated from NADPH molecules.

The utilization of electron donors for Cr(VI) reduction is species-dependent, and the reduction rate in specific microorganisms also varies for different sources (Das et al., 2014; Zhang et al., 2018). The electron donor that is effective in catalyzing Cr(VI) reduction for one microorganism might not be as useful for other species. It is also highly probable that multiple reduction pathways of variable efficiencies can be operated for different electron donors in different species. The capacity of electron donation of different donor compounds also relies on a mobile cytochrome electron carrier, quinone pool, or a dehydrogenase activity, where the measures of decreased potential differences between donor and acceptor compound states matter (Kracke et al., 2015). However, if the available electron donors are not suitable for any microorganism, adverse impacts on both growth and reduction process are noticeable. For example, Cr(VI) can be more toxic to microbes, when ethanol or butyrate is the sole electron donor as compared to more favorable glucose or lactate (Field et al., 2018). The cells in aerobic systems cannot gain enough energy from butyrate or ethanol for growth. Therefore, the availability of electrons for Cr(VI) reduction remains insufficient. Moreover, the presence of ethanol decreases the cell viability by shearing biological membrane, and metabolically active cells become more susceptible to alcohol and Cr(VI) uptake and their toxicity. Nevertheless, some anaerobic conditions have utilized the route of oxidation of ethanol by sulfate reducing bacteria for Cr(VI) removal (Pagnanelli et al., 2012; Cirik et al., 2013).

In recent years, microbial synergy has been used to couple various electron donors for effective Cr(VI) reduction process (Lu et al., 2020; Shi et al., 2020a). The outcomes have demonstrated obvious improvement in Cr(VI) reduction. The utilization of both hydrogen and methane (CH_4) as dual electron donors involving microbial consortia of autohydrogenotrophic bacteria (e.g., *Hydrogenophaga*, *Thiobacillus*, and *Acetoanaerobium*), CH_4–metabolizing microorganisms (e.g., *Methanobacterium* and *Methanosaeta*), and heterotrophic Cr(VI) reducers (e.g., *Geobacter*, *Spirochaetaceae*, *Delftia*, and *Anaerolineaceae*) promoted Cr(VI) reduction in different bioreactors (He et al., 2020, 2021). However, microbial anaerobic Cr(VI) reduction using hydrogen (H_2) or CH_4 as an individual electron donor also persists, but the capacity of removal is limited in different aspects (Chung et al., 2006, 2007; Lai et al., 2016; Luo et al., 2019). In a CH_4-based membrane biofilm reactor (MBfR), metagenomics analysis showed that oxidation of CH_4 by a sole anaerobic methanotroph, *Candidatus* "Methanoperedens," in the biofilm was responsible for Cr(VI) reduction (Luo et al., 2019). Another MBfR exhibited relative abundance of three genera *Methylocystis*, *Meiothermus*, and *Ferruginibacter*, which was coupled with CH_4 oxidation, and Cr(VI), Se(VI), and SO_4^{2-} reduction (Lv et al., 2018). In other ways, S(0) or Fe(0) can also be used as inorganic electron donors for biologically Cr(VI) reduction employing microbial synergism. Shi et al. (2019) found that VFAs produced by Fe(0) or S(0) oxidizing bacteria (e.g., *Thiobacillus* or *Ferrovibrio*) could be utilized by Cr(VI) reducer (e.g., *Geobacter* or *Desulfovibrio*). Another sulfur-based mixotrophic Cr(VI) reduction process involved autotrophic sulfur oxidation and heterotrophic chromate reducing bacteria such as *Desulfovibrio* and *Desulfuromonas* (Zhang et al., 2020). The coupling of different processes such as microbial sulfur cycle, Fe(III)/Fe(II) transformation, phenol degradation, and Cr(VI) reduction by microbial aggregates involving bacteria such as *Desulfovibrio*, *Comamonas*, *Ochrobactrum*, and *Thiobacillus* offered effective and simultaneous removal of multiple contaminants including Cr(VI) and also facilitated the reduction of the reoxidized Cr(III) (Zhao et al., 2020b). Recently, the mixed biogas forms, CH_4 and hydrogen, regulated by bacteria such as *Geobacter* and *Methanobacterium* in a microbial fuel cell (MFC) promoted Cr(VI) reduction by Cr(VI) reducers (e.g., *Hydrogenophaga*, *Thiobacillus*, *Geobacter*, and *Anaerolineaceae*) coupled with hydrogen-oxidizing bacteria (e.g., *Hydrogenophaga* and *Thiobacillus*) and CH_4-oxidizing bacteria (e.g., *Methanobacterium* and *Methanosaeta*) (He et al., 2021).

Microbes are further known to utilize composite matters or combinations of donor compounds for Cr(VI) reduction (**Figure 2**; Shi et al., 2012; Mala et al., 2015; Huang et al., 2019). Abundant natural substances such as cellulose, hemicellulose, pectin, starch, and xylose can be the bulk sources of reducing equivalents like NADH and reduced ferredoxin during the metabolic route of glucose fermentation (Bai et al., 2018). Cellulosic waste that can be biodegraded to other carbon sources such as sugars, organic acids, and alcohols can readily stimulate bacterial growth and the subsequent reduction of Cr(VI) (Thomas et al., 2016; Field et al., 2018). This was also supported by an observation where Cr stress situation enhanced production of cellulase enzyme for the hydrolysis of cellulose (Aslam et al., 2019). Another study measured the coupling of cellulose and cellulose-degrading bacterium, *Cellulomonas* strain Lsc-8 in an MFC to reduce Cr(VI), and generated electricity simultaneously (Cao et al., 2020). Emulsified vegetable oil (EVO) and molasses as carbon sources have also influenced the biological metabolism to promote Cr(VI) reduction (Michailides et al., 2015; Wen et al., 2017). EVO being an oil-in-water emulsion operated as a slowly released electron donor by fermenting into acetate and hydrogen (Wen et al., 2017). EVO has advantages over other soluble substrates for Cr(VI) reduction, as it can provide long-term electrons for the biological process by inhibiting rapid biodegradation, and downgradient migration (Wen et al., 2017). Likewise, another solid substrate, cellulose-rich materials as a biodegradable meal box (BMB) also exhibited property of slowly releasing electrons for Cr(VI) reduction (Li et al., 2016). Molasses as an economical and readily available carbon source have offered more efficient Cr(VI) reduction than by many other sugars. The superiority of molasses over other carbon sources in Cr(VI) reduction can be attributed to its diverse constituents such as nitrogenous substances, vitamins, trace elements, and a large amount of different sugars (Smith et al., 2002; Field et al., 2013). Also, the presence of more easily utilizable sugars in molasses can be presumably more effective than pure sucrose for electron donating capability (Field et al., 2013). The phenolic hydroxyl and carbonyl groups of reducing substances such as flavonoids in molasses might also supply the electrons to the Cr(VI) (Okello et al., 2012; Chen et al., 2015). Complex nutrient media such as yeast extract and peptone can act as energy substances to support natural microbial communities, which rapidly increase the biological Cr(VI) reduction (Ancona et al., 2020; Dey and Paul, 2020). Possibly, such constituents in different culture media have always influenced the Cr(VI) reduction process by electron donating property as well. In contrary, some organic constituents in complex matters can interfere with the bioavailability of Cr(VI) for its reduction (Dey and Paul, 2020). Also, the competition of electron donors for the reduction of other co-contaminants such as SO_4^{2-}, NO_3^-, and Se(VI) might often impede with enhanced Cr(VI) reduction (Zhong et al., 2017; Lv et al., 2018). But the advantage lies as the oxidation of organic compounds preferentially donates electrons to Cr(VI) over many other acceptor molecules considering its high reducing potential (Cirik et al., 2013).

ELECTRON MEDIATORS (OR ELECTRON SHUTTLES)

Extracellular reduction may require some passage capacity for intracellular reducing equivalents to approach exterior Cr(VI). Such pathway raises the value of electron mediators (or electron shuttle) for reduction outside the cell (Bai et al., 2018). Mediators can reversibly reduce and oxidize to shuttle electrons from cellular boundary to terminal electron acceptor [i.e., Cr(VI)] (Han et al., 2016; Tanaka et al., 2018; Cheng et al., 2019). In this process, complexes such as porin-cytochrome located on the bacterial membrane can provide an interface for the transfer of intracellular electrons using redox mediators (Richardson et al., 2013). Mediators have a role in accelerating the reducing activity rather than promotion effect on the Cr(VI) reduction (Huang et al., 2019). Because such additives can prominently speed up the electron transfer rate (Cheng et al., 2019). Such chemical reaction is feasible when the standard redox potential of an electron mediator lies between the standard redox potentials of two half-reactions (Kavita and Keharia, 2012). In this conversion, electrons can readily shuttle from low-potential electron donors to mediators and then from low-potential mediators to the terminal electron acceptor, i.e., Cr(VI). Consequently, mere contacts among such components are sufficient for the catalysis of the Cr(VI) reduction (Voordeckers et al., 2010). The most suitable range of redox potential for mediators to succeed Cr(VI) reduction lies between −0.320 and 1.28 V, where the previous value belongs to cofactor NADPH, and the latter for chromate (Kavita and Keharia, 2012). Some redox mediators are also reported to overcome thermodynamic barriers of redox conversions and steric hindrance of the reactants (Sun et al., 2015; Dai et al., 2016). Appropriate concentrations of electron donors are also a crucial factor for the regeneration of mediators, whereas the absence of suitable electron donors may substantially hamper the activity of mediators (Chen et al., 2011; Xafenias et al., 2013; Bai et al., 2018). Many investigations identified that electron mediators could exhibit a concentration-dependent effect on Cr(VI) reduction (Rahman and Singh, 2014; Mahmood et al., 2015; Huang et al., 2016), because high concentrations of the mediator compounds could arouse inhibitory effects on microbial growth and its metabolic activity (Wolf et al., 2009; He et al., 2020).

Electron mediators for Cr(VI) reduction belong to a diverse range of organic compounds of foreign origins and endogenous metabolism and can involve some heavy metals (**Figure 3**; Smutok et al., 2011; Xafenias et al., 2013; Huang et al., 2019; Cao et al., 2020). Often organic mediators are heterocyclic aromatic rings possessing conjugated bonds that enable reduction and rearrangement at biologically accessible reduction potentials (Chai et al., 2019). Various humic substances and their quinoid analogs such as lawsone, menadione, anthraquinone (AQ), anthraquinone-1-sulfonate (α-AQS), anthraquinone 2-sulfonate (AQS), anthraquinone-1,5-disulfonate (1,5-AQDS), anthraquinone-2,6-disulfonate (AQDS), anthraquinone-2,7-disulfonate (2,7-AQDS), 1-chloroanthraquinone (1-CAQ), 1,5-dichloroanthraquinone (1,5-DCAQ), 1,4,5,8-tetrachloroanthraquinone (1,4,5,8-TCAQ), etc., have been popularly used to increase the electron transfer rate for microbial Cr(VI) reduction (Guo et al., 2012; Hong et al., 2012; Huang et al., 2019). Mainly, the carboxyl and phenolic hydroxyl groups present in quinoid compounds of mediators take accountability for the redox conversions between electron donors and the high valence state of the metal (Xu et al., 2020). The position and the presence of chloride ion(s) and other substituents in the aforementioned quinoid compounds also influence electron transfer limitations in Cr(VI) reduction (Hong et al., 2012; Zhang et al., 2014; Dai et al., 2016; Lian et al., 2016). In some investigations, the synergistic associations of Fe(III) minerals and AQDS were involved to deliver an alternative and attractive strategy of enhanced Cr(VI) reduction for co-contaminated sites using microorganisms like *Cellulomonas* sp., *Shewanella oneidensis*, and *Geobacter sulfurreducens* (Field et al., 2013; Meng et al., 2018; He et al., 2019; Liu et al., 2019b). This association employed Fe(III) reduction, and the biogenic product of this reaction, Fe(II), made possible catalysis of Cr(VI) reduction, where AQDS served as an electron carrier between the electron donor and Fe(III). However, the unaccompanied employment of Fe(III) produced lower effect on Cr(VI) reduction because of insoluble nature of the metal ion (Sharma, 2002). In another study, the biomass of henna plant showed a dual role as electron donor and

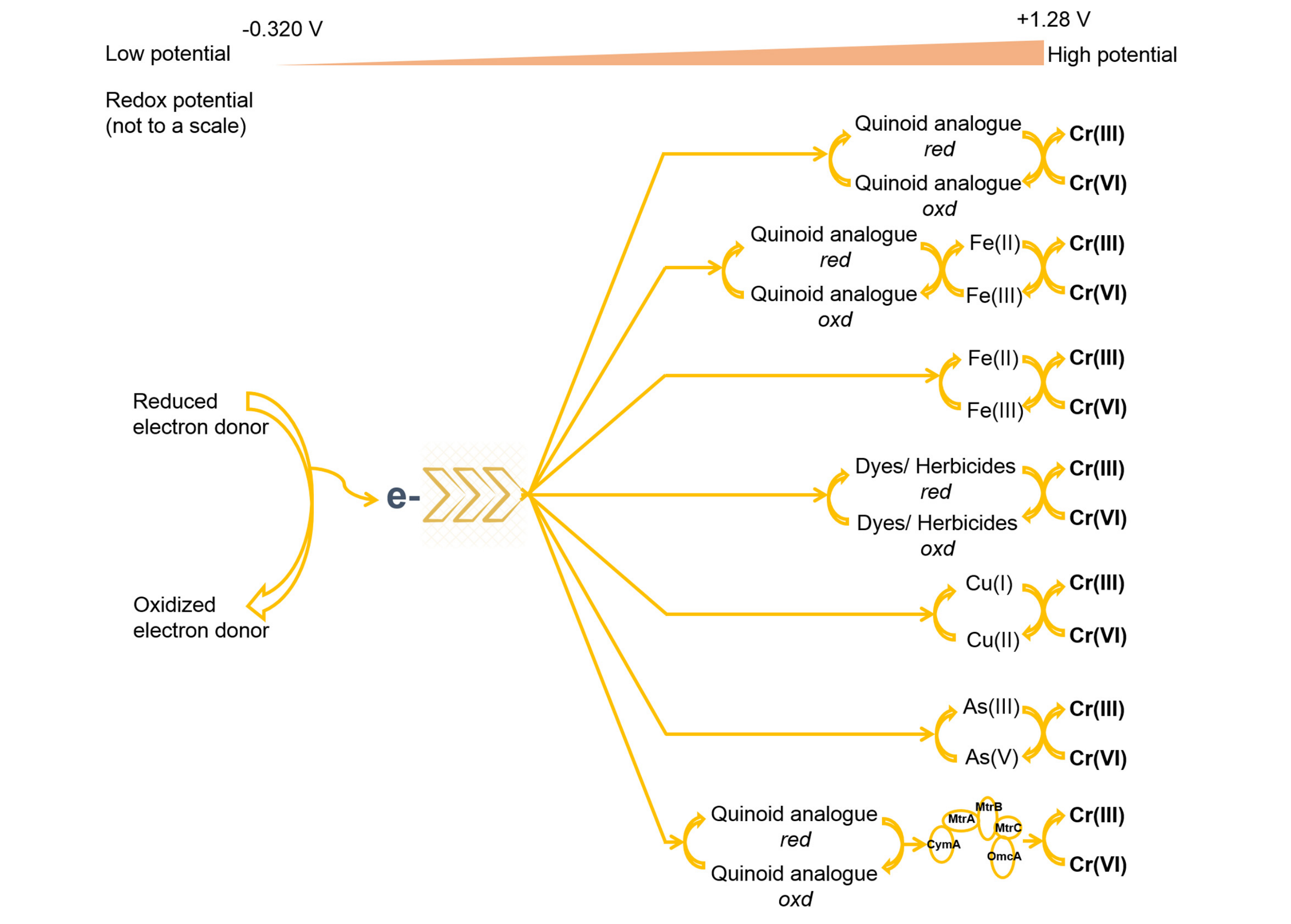

FIGURE 3 | The utilization of various electron donors for Cr(VI) reduction. EVO and ETS mean emulsified vegetable oil and electron transport system, respectively. Sign represents assimilation.

redox mediator for Cr(VI) reduction. A compound, lawsone, present in the biomass displayed rate-enhancing effect on Cr(VI) reduction, whereas the VFAs and H_2 produced from hydrolysis and fermentation of carbohydrate and protein supplied electrons for reduction (Liu et al., 2010; Huang et al., 2016). Various other organic compounds such as riboflavin, uric acid, dissolved organic matter, etc., have also enhanced the performance of Cr(VI) reduction by shuttling electrons from different microbial metabolisms (Xafenias et al., 2013; Mahmood et al., 2015; He et al., 2020). Another cellular metabolite, pyrrole-2-carboxylic acid ($C_5H_5NO_2$), also accelerated the bioreduction process in presence of high Cr(VI) concentration by *P. phragmitetus* BB (Chai et al., 2019). Interestingly, the EPSs in a sulfur-reducing bacterium, *Enterococcus avium* strain BY7, were also reported to support as an electron carrier for Cr(VI) reduction, where different EPS components such as polysaccharides, proteins, and humic substances exhibited dissimilar electron transfer rates (Yan et al., 2020). Further, the self-assembly of strain BY7 on reduced graphene oxide (rGO) showed enhanced EPS production on bacterial surface for increased removal of Cr(VI). However, the crucial role of rGO in this association involved in reduction of Cr(III) into elemental Cr (a rare species) by lowering electronic potential or activation energy. Several dyes such as methylene blue, neutral dye, dichlorophenolindophenol (DCPIP), meldola blue, and Nile blue have also possessed electron transfer efficiency for Cr(VI) reduction in different fungal and bacterial cells (Smutok et al., 2011; Bai et al., 2018). Simultaneous removal of dyes along with Cr(VI) sets another reputation for their involvement in this reaction. However, such prominence is more suitable, when dyes act as electron donors. Two herbicides, ethyl and methyl viologens, which have been commonly used as mediators for biotransformation of different chemical pollutants, were also employed in Cr(VI) reduction. But the very low redox potential of viologen compounds weakened their roles for Cr(VI) reduction and procured only limited accelerations (Kavita and Keharia, 2012). Some heavy metals such as Cu, Fe(III), and As(III) acting as mediators have also accelerated the enzyme activity for Cr(VI) reduction (details in the following subsection). The role of Cu as a mediator in Cr(VI) transformation is very prominent in various microorganisms. Several Cr(VI) reducers such as *Enterobacter* sp. DU17, *Bacillus* spp., *Pseudomonas putida* KI, *Ochrobactrum* sp. strain CSCr-3, *Brevibacterium* sp. K1, and *Stenotrophomonas* sp. D6, etc., have shown positive effects of Cu on reduction process using different approaches (Camargo et al., 2003; Desai et al., 2008; He et al., 2009; Rahman and Singh, 2014; Ge et al., 2015; Mahmood et al., 2015). Wang et al. (2017b) showed that Fe(III) as an electron shuttle stimulated 1.6-fold more reduction of Cr(VI) in an MFC.

Different mediator compounds have shown different electron transfer competence for Cr(VI) reduction (Wang and Jia, 2007; Liu et al., 2010; Cheng et al., 2019). For example, the addition of AQS greatly improved electron transfer efficiency in *Escherichia coli* BL21, complying 98.5% Cr(VI) reduction, whereas the presence of α-AQS, 1,5-AQDS, AQDS, and 2,7-AQDS could enable only 21–34% metal reduction (Guo et al., 2012). Another investigation reported increased rate of Cr(VI) reduction by *E. coli* K12 using different shuttles following an order of lawsone > menadione > AQS > AQDS (Liu et al., 2010). Even many microorganisms exhibited the ability to utilize multiple electron mediators for the acceleration of Cr(VI) reduction rate (Field et al., 2013; Huang et al., 2019; He et al., 2020). In different studies, redox mediators were also reported to alter the electron transfer pathway of some microorganisms for Cr(VI) reduction (Yan et al., 2014; Dai et al., 2016). The suitable example is the supply of 2-amino-3-chloro-1,4-naphthoquinone-GO (NQ-GO) in *Acinetobacter* sp. HK-1, which shifted and promoted electron transfer from cytoplasmic fraction to membrane counterpart for extracellular Cr(VI) reduction (Zhang et al., 2014). The electron transfer competence of different redox mediators also varies in different microorganisms, where several other factors may administer different stimulation. In many anaerobic conditions, electrons can be shuttled by series of membrane-associated proteins, where the adsorbed Cr(VI) onto cell surface can be subsequently reduced using various membrane-bound reductases (Komori et al., 1989; Wang et al., 1990; Zhu et al., 2008; Belchik et al., 2011; Cao et al., 2020). In *S. oneidensis* MR-1, the quinone/quinol pool in the cytoplasmic membrane transferred the electron from inner membrane across outer membrane through periplasm using network formed by cytochrome c (cyt c), where the outer membrane decaheme cyt c molecules, MtrC and OmcA, played major roles in the transfer of electrons to Cr(VI) on the cell surface using electron shuttles (Belchik et al., 2011).

Immobilization of redox mediators onto different substances for Cr(VI) reduction has also received attention for their better stability, reusability, and persistence. Moreover, lessening the toxic effects of mediator compounds on microbes by their immobilization is also evident (He et al., 2020). Lian et al. (2016) observed nearly 4.5-fold increase in Cr(VI) reduction rate using shuttle facility from 1-CAQ cellulose acetate beads involving bacterium, *Mangrovibacter plantisponsor*. Additionally, many previous MFCs have developed synthetic conductive polymers such as polypyrrole/9, 10-anthraquinone-2-sulfonic acid sodium salt, Si-carbide derived carbon cathode, rutile-modified polished graphite rod, etc., as insoluble redox mediators for improved concurrent Cr(VI) removal and bioelectricity production (Li et al., 2009; Pang et al., 2013; Gupta et al., 2017; Wang et al., 2017b; Li and Zhou, 2019). **Table 3** provides information on the measured capacity of different redox mediators for Cr(VI) reduction by different microorganisms.

TABLE 3 | Acceleration of Cr(VI) reduction by various electron mediators (electron shuttles) using microorganisms.

Microorganisms	Electron mediators	Cr(VI) concentration	Cr(VI) removal				References
			In absence of other additives		In presence of other additives		
			% reduction	Time duration (h)	% reduction	Time duration (h)	
Bacillus firmus TE7	As(III)	100 mg/L	100	60	100	48	Bachate et al., 2013
Bacillus sp. 3C3	Anthraquinone 2-sulfonate (AQS)	0.5 mM	13.7	72	39.5	72	Hong et al., 2012
Escherichia coli BL21	AQS	0.8 mM	21	7.5	98.5	7.5	Guo et al., 2012
Pseudomonas putida KI	Hydroquinone	1 mM	68	12	97	12	Mahmood et al., 2015
	Uric acid	1 mM	~80	18	92	18	
Enterobacter sp. DU17	Cu(II)	50 mg/l	~61	24	91	24	Rahman and Singh, 2014
	As(III)	100 mg/l	~61	24	75	24	
Escherichia coli K12	Lawsone	0.2 mM	6.8	4	97.5	4	Liu et al., 2010
	Menadione	0.2 mM	6.8	4	91.9	4	
	AQS	0.2 mM	6.8	4	79.0	4	
Acinetobacter sp. HK-1	2-amino-3-chloro-1,4-naphthoquinone-GO (NQ-GO)	5.0 mg/L	9.5	11	100	11	Zhang et al., 2014
Pannonibacter phragmitetus BB	Pyrrole-2-carboxylic acid ($C_5H_5NO_2$)	3.0 mM	~8.0	6	~20	6	Chai et al., 2019

OTHER CHEMICAL INFLUENCES

The role of chemicals beyond electron donors and mediators for improved Cr(VI) reduction also exists. A variety of chemical affluences acquires diverse mechanisms to advance Cr(VI) reduction process. Even some electron donors and mediators have enhanced Cr(VI) reduction involving other procedures. For examples, heavy metals such as Cu(II), As(III), and Fe(III) that acted as shuttles to accelerate Cr(VI) reduction activity have also upgraded reduction performance by some other effects. Few bacteria recognized Cu as a protective agent for oxygen-sensitive chromate reductase in Cr(VI) reduction (Ibrahim et al., 2012). This metal was also reported to trigger a Cr(VI) reducing enzyme, NAD(P)H-favin oxidoreductase (NfoR), by acting as ligand and changing the enzyme conformation (Han et al., 2017). In a different study, employment of CuO nanoparticles on a biological system activated multiple redox enzymes, and sulfur- and nitrogen-containing proteins for the positive effects on Cr(VI) bioreduction (Yan et al., 2019). A Cu-dependent Cr(VI) reductase is also evident in a bacterium, *Amphibacillus* sp. KSUCr3 (Ibrahim et al., 2012). However, Cu does not necessarily produce encouraging results in all Cr(VI) reducers. Many microorganisms have also experienced the inhibitory effects on Cr(VI) reduction for the effect of Cu (Wang et al., 1990; Park et al., 2000; Pal et al., 2005). A membrane-bound chromate reductase of *Enterobacter cloacae* displayed negative effects after exposure to Cu (Wang et al., 1990). Also, the addition of Cu altered electron transfer pathway and Cr(VI) reduction ability by inhibiting Ni-Fe hydrogenase activity in *Caldicellulosiruptor saccharolyticus* (Bai et al., 2018). Likewise, As(III) also showed varied roles for enhancing Cr(VI) reduction in different microorganisms. A study identified the surplus concentration of As(III) increased the Cr(VI) reduction rate involving *Bacillus firmus* TE7, and complete reduction was observed within 48 h, which was otherwise 60 h (Bachate et al., 2013). This instance sets an example of As(III) as an electron shuttle. In another study, *Enterobacter* sp. Z1 could positively influence the efficiency of Cr(VI) reduction from 64.5 to 92.8% after addition of As(III) within 7 days of incubation (Shi et al., 2020b). In this process, two different mechanisms were proposed for the role of As(III) in enhanced Cr(VI) reduction. In one aspect, As(III) could act as an inducer for the synthesis of cysteine and other sulfur-containing molecules to improve Cr(VI) reduction. Another scheme advised that As(III) as an electron donor might enable redox conversion of Cr(VI). Many other divalent metal ions such as Co(II), Mn(II), Ni(II), Mg(II), Zn(II), and Pb(II) and a monovalent metal ion Ag(I), which usually inhibit chromate reductase activity or produce no significant effect on reduction process, have also promoted Cr(VI) reduction by different bacterial species in various studies (Camargo et al., 2003; Elangovan et al., 2006; Sultan and Hasnain, 2007; He et al., 2009; Liu et al., 2010; Dey and Paul, 2015; Ge et al., 2015; Han et al., 2017; Bansal et al., 2019). However, the exact mechanisms of Cr(VI) bioreduction under the influence of many such metals are yet to be identified. In recent years, the co-presence of another heavy metal, vanadium V(V), has received popularity for their simultaneous removal (Zhang et al., 2012; Wang et al., 2017a, 2018; Shi et al., 2020a). Both Cr(VI) and V(V) have high reducing potential and can be reduced utilizing the same electron sources. But Cr(VI) reduction is preferential and can be enhanced by suppression of V(VI) reduction (Wang et al., 2018; Shi et al., 2020a). Also, this simultaneous removal process involved inhabited approach for V(V) reduction (Wang et al., 2017a). Addition of Ca(II) in the medium weakened the damage of Cr(VI) and promoted Cr(VI) reduction by *Penicillium oxalicum* SL2. The main role of this divalent cation was in stimulating the synthesis of calcium oxalate crystals for maintaining the integrity of cell wall (Luo et al., 2020). Amendment of Na(I) contributed to an increase in the activity of Cr(VI) reduction by the yeast, *Pichia jadinii* M9, where the role of monovalent cation in the bioprocess remained unidentified (Martorell et al., 2012). Even a metabolic inhibitor, 2,4-di nitrophenol (DNP), has also promoted Cr(VI) reduction activity in some Cr(VI) bioreducers (Wani et al., 2007; Alam and Ahmad, 2012; Dey and Paul, 2015). The stimulation of Cr(VI) reduction by DNP is attributed to the fact that its involvement as a decoupling agent could enhance the electron flow in electron transport system, thereby using Cr(VI) as a terminal electron acceptor for maximum reduction under oxygen-limiting conditions (Wani et al., 2007; Alam and Ahmad, 2012). The anionic surfactant, sodium dodecyl sulfate has also influenced the removal efficiency by partitioning of protons due to electrostatic attraction (Nandi et al., 2017). Another anion, ${SO_4}^{-2}$ also ensured increased Cr(VI) reduction by improving cell growth in some species (Bonilla et al., 2016; He et al., 2019). In a different way, the synthesis of thiol compounds from ${SO_4}^{-2}$ alleviated the oxidative stress of Cr(VI), which accelerated Cr(VI) reduction (Luo et al., 2020). ${NO_3}^{-}$-N as the sole nitrogen source also promoted Cr(VI) reduction by *Pseudomonas brassicacearum* LZ-4 (Yu et al., 2016). In another study, the supplement of phosphorus mineral enriched genes related to metal reduction; denitrification; carbon, nitrogen, and phosphorus cycles for the absorption of nutrient synthesis; and electron shuttles for improved Cr(VI) reduction (Ma et al., 2020). Adenylate cyclase expressing *S. oneidensis* MR−1 exhibited enhanced bidirectional EET and Cr(VI) reduction capacities. This was attributed to increased production of cyclic adenosine 3′,5′−monophosphate (cAMP) and cAMP-receptor protein system, which enhanced the gene expression of c−type cytochromes and flavins synthetic pathways for Cr(VI) reduction (Cheng et al., 2020). Similarly, the outer membranes of *Geobacter* spp. with sulfate transporter proteins and cytochromes were critical to metal reduction (Shi et al., 2009; Santos et al., 2015). The enhanced Cr(VI) reduction by microorganisms for the various roles of different chemical additives beyond electron donors and mediators is illustrated in **Figure 4**.

ROLE OF VARIOUS CHEMICAL ADDITIVES IN *EX SITU* AND *IN SITU* APPLICATIONS

Development of bioreduction technology for large-scale applications involved a multitude of interactions and biomolecular engineering to multiscale integration. Several

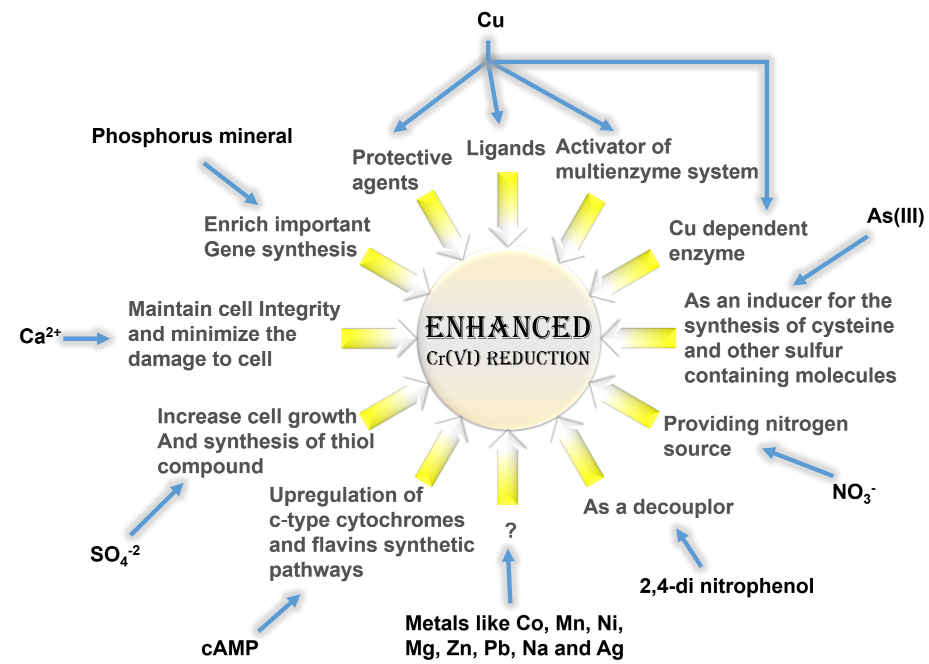

FIGURE 4 | Different pathways for accelerated Cr(VI) reduction using different electron mediators.

key factors are critical to the successful implementation of chemical additives in bioreduction of Cr(VI). Often local physicochemical characteristics present different challenges for the effectiveness of the reduction reaction. For example, reduction of Cr(VI) in contaminated environment can be influenced by the presence of different electron acceptors including O_2, Fe, Mn, nitrate, etc., which can variably shift the movement of electrons (Sharma, 2002).

Lu et al. (2020) found that natural material, mackinawite, could be effectively operated as electron donors by a neutrophilic chemoautotroph, *Acidovorax* in a batch bioreactor, and the intermediate microbial physiological constituents, VFAs, released from mineral bio-oxidation, could enable the shuttle of electrons to Cr(VI) involving a reducer like *Geobacter*. In an up-flow anaerobic sludge bed reactor, the population of genus *Trichococcus* greatly increased toward the operation period of Cr(VI) reduction using anaerobic sludge, which mainly attributed to fermentation of organic complexes to be available as electron donors, where genera like *Desulfovibrio*, *Ochrobactrum*, and *Anaerovorax* were the main Cr(VI) reducers (Qian et al., 2017). Anaerobic digestion using various electron donors have shown high efficiency of Cr(VI) reduction in different bioreactors (Wang et al., 2018; Zheng et al., 2019). A large laboratory-scale experiment of a 512-day period identified that injection of EVO in Cr(VI)-contaminated aquifer created an acidic and reducing environment, which facilitated Cr(VI) bioreduction by bacteria. Amendment of EVO also greatly influenced microbial community structure and diversity toward the abundance of EVO biodegradation capabilities, which aided supply of reducing equivalents for Cr(VI) reduction (Dong et al., 2018). Additionally, the utilization of bioelectrochemical systems in the form of microbial electrolysis cell (MEC) and MFC is also an innovative route to sustainable bioremediation of Cr(VI)-polluted groundwater (Li et al., 2019b; He et al., 2021). The biogas hydrogen (H_2) and CH_4 produced in MEC can serve as electron donors for Cr(VI) bioreduction involving synergism of autohydrogenotrophic genus, CH_4-metabolizing microorganisms and Cr(VI) reducers (He et al., 2020). Elevated Cr(VI) reduction is greatly convenient in MFC, and simultaneous power generation and removal of co-contaminants were achieved using different variants (Pophali et al., 2020; Zhao et al., 2020a). Yang et al. (2020) showed that compost-derived humic acid along with hematite could promote Cr(VI) reduction by strain MR-1, where the quinonoid and acid groups in organic substances exhibited role as electron shuttle and electron donor, respectively. In a microcosm assay, biostimulation of acetate was effective for anaerobic Cr(VI) treatment in highly alkaline and saline soil of long-term contaminated landfill of León (Guanajuato), Mexico, where a haloalkaliphilic isolate, *Halomonas*, was expected to lead the catalysis of Cr(VI) reduction (Lara et al., 2017). Treatment of Cr(VI)-contaminated soil from tannery site with *Pseudomonas* sp. (RPT) revealed enhancement of Cr(VI) reduction after biostimulation of neem (*Azadirachta indica*) oil cake (NOC), and the application of NOC further improved soil enzyme properties (Govarthanan et al., 2019). Habitually, indigenous microbial communities of different sites greatly influence the reduction process (Lara et al., 2017).

In situ amendment of AQSD shifted dynamic state of non-equilibrium transformation of Cr toward accelerated Cr(VI) reduction and inhibited Cr(III) oxidation in contaminated soil (Brose and James, 2010). In a field-scale investigation at Hanford's 100 area of the United States Department of Energy facility, researchers employed a stable carbon isotope of sodium lactate (13C-labeled) to monitor biostimulation and electron donor fate for Cr(VI) reduction into the high-permeability aquifer comprising gravel and coarse sand sediments (Bill et al., 2019). Several lines of evidence in this study suggested that original ^{13}C-lactate underwent some microbial metabolic pathways through total organic carbon (TOC), acetate, and propionate to complete mineralization by serving as electron donors for Cr(VI) reduction. In another study, amendment of organic matter followed by bioaugmentation with a consortium of actinobacteria greatly influenced the Cr(VI) reduction in soil (Lacalle et al., 2020).

CONCLUSION AND FUTURE PERSPECTIVES

The perplexing task of removing Cr(VI) contamination from the environment has led to the development of various bioremediation approaches, particularly the proficient reduction strategies by microorganisms. However, the high efficiency of large-scale microbial Cr(VI) reduction can be limited by the availability of various chemical factors, mainly electron donors, mediators, and cofactors. The oxidation of many suitable chemicals (as electron donors) enables supply of electrons to Cr(VI) to facilitate enhanced reduction. The use of composite matters or combinations of chemical compounds as electron donors grants additional benefits for large- scale application, considering economic aspects. Presence of mediator molecules takes part in improvement of the dynamics of bioreaction. Moreover, several chemicals achieve merits for Cr(VI) bioreduction involving diverse roles other than electron donors and electron mediators. Very often the information on aforementioned chemicals supports their employment for *in situ* and *ex situ* Cr(VI) bioremediation.

Chemical-assisted microbially mediated Cr(VI) reduction is sustainable only when the chemical dosages are low. Otherwise, their high concentrations may cause secondary pollution, impede the ecofriendly approach, and lose prospect of preserving the natural resources particularly for *in situ* applications. Although aforementioned facilities for Cr(VI) bioreduction also exist in environment through natural attenuation at limited efficiencies, in-depth understanding of the governing procedures can device commercial exploitation of the processes for enhanced removal approaches. Therefore, there is a necessity for developing eco-biotechnological schemes that could use unexploited potential of the natural ecosystems for remediation of Cr(VI) contaminated environment. Several key points important to successful application of chemical additives for improved Cr(VI) bioreduction are as follows:

- Identification of novel microbial isolates with better reduction capacity from different environmental samples and their enhanced reducing activity under various chemical affluences are foreseen.
- New knowledge of diverse and specific reduction mechanisms involving chemical consolidation can be constructive in devising effective Cr(VI) treatment.
- The choices of appropriate chemical sources as electron donors, mediators, and cofactors for different microorganisms are important to be recognized.
- Identification of green chemicals for the stimulation of Cr(VI) bioreduction is highly desirable considering the sustainability of ecofunctioning.
- Employment of indigenous chemicals as the substitute for foreign substances may provide better compatibility for the treatment of the contaminated system.
- Employment of wastes generated from other industries may contribute as the cheap alternatives for the Cr(VI) reduction process.
- The electron-donating abilities of different electron donors from composite matters are subject too difficult to analyze, but such integration to biological Cr(VI) reduction for large-scale application and economical virtue states matter.
- The capacity of utilizing endogenous microbial metabolites for reduction process is also rational.
- Chemical integration of donor and mediator compounds often implicates a complex system for Cr(VI) reduction, involving various pathways and processes and multilevel interactions. Such phenomena are also needed to be addressed in-depth.
- The involvement and interaction of numerous compounds by microbial synergy in different intricate pathways have received little attention and therefore warrant further investigations.
- The regular monitoring of microbial growth and Cr(VI) reduction for the treatment of specific chemical utilized for the process is crucial. Moreover, the parameter of soil enzyme activities of the native microbial flora should also be analyzed to identify the various effects of chemical additives.
- The role of many chemicals on Cr(VI) bioreduction is poorly understood, and their characterization relies mainly on past studies. For the same, advanced "omics" technology can add more sight on their specific involvements.
- Variously, genetic manipulation of certain genes of different bioreducers can also empower the microbial ability to exploit various chemical affluences for enhanced Cr(VI) removal.

AUTHOR CONTRIBUTIONS

Both authors of this manuscript have made equal contributions to writing, formation of tables and diagrams, editing, and approved it for publication.

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Conflict of Interest: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

بيانات عن الكتاب

اسم الكتاب : الهند والعرب: ثقافةً وحضارةً

جمع وتحرير : د. محمد آفتاب أحمد/ د. محمد قاسم العادل

سنة النشر : 2021م

عدد الصفحات : 462

ثمن النسخة : 340 روبية

عدد النسخ : 500

الناشر : مركزي ببليكيشانز، جوغابائي، جامعة نغر، نيو دلهي- 25

Name of the Book:

INDIA AND THE ARABS

Civilization and Culture

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ISBN : 978-81-950288-0-1

Printed by:
Markazi Publications
S-17/4, Jogabai Ext. Jamia Nagar, New Delhi -25
Cont.: +91-9811794822/21
E-mail: markazipublication@gmail.com

الدراسات الإسلامية في الهند

الهند والهنود في كتابات العرب

السيرة النبوية باللغة العربية في الهند

الدكتور نسيم أحمد

الملخص:

لقد اهتم علماء المسلمين الهنود بكتابة السيرة النبوية باللغة العربية منذ فجر التاريخ الإسلامي في الهند فظهرت فيها دراسات ومؤلفات في السيرة النبوية تتخذ طوابع مختلفة، فمنها ما يحرص على تدوين السيرة النبوية الكاملة، ومنها ما يهدف إلي اختصارها وتلخيصها، ومنها ما يعني بالدروس الدينية والتربوية المستقاة منها، ومنها ما يطمح إلى التحقيق من بعض الوقائع والأ قوال إلى غير ذلك. هذه الورقة تناول التطور العلمي لفن السيرة النبوية في الهند و تبرز إسهامات علماء الهند فيها باللغة العربية عبر القرون منذ دخول الإسلام أرض الهند حتى يومنا هذا، وتحديد مداها تحديدا صحيحا مناسبا وتقويمها تقويما موضوعيا بدون الخوض في الإسهامات التي تمت باللغات الهندية الأخري. وهذه الورقة تلفت الانتباه أيضا إلى الحقيقة بأن العلماء الهنود لم يحرزوا من التقدم العلمي والتحقيقي ما أحرزه علماء السيرة باللغة الأردية ولم تبلغ كتبهم المقام الذي بلغت إليه الكتب الأردية في هذا المجال من حيث البحث العلمي والتحقيق التاريخي.

India-Vietnam

Enhancing Partnership

India-Vietnam
Enhancing Partnership

Editors

Jayachandra Reddy G
Nguyen Xuan Trung

JAYA Publishing House

First Edition 2020

ISBN : 978-93-89695-96-0

Published by:

JAYA PUBLISHING HOUSE

Publisher and Distributor

H-1/60, Sector - 16, Rohini, Delhi-110089 (INDIA)
Ph: +91-11-43501867, 91-9891277233
Email: info@jphindia.com, jayapublishinghouse@gmail.com
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Contents

Preface

As the Golden Jubilee of establishment of full diplomatic relations between India and Vietnam (7 January 1972) is a couple of years away, bilateral relations of India and Vietnam are poised to scale new heights. Shared interests and concerns form a solid base, for India-Vietnam relations, the two sides have paid special attention to the strengthening of bilateral relations over the past years. India and Vietnam mutually attach great importance in their development strategies. India's ties with Vietnam and the rest of the countries of the ASEAN region remain a key factor in maintaining the balance of power in the Indo-Pacific region. Curiously, India, Russia and China are three comprehensive strategic partners of Vietnam. In this context, India attaches great importance to Vietnam in the ASEAN region as well as in its Act East policy.

The India-Vietnam bilateral relationship growing in both width and depth and this prompted the two countries to be called as natural allies. In the rapidly changing international and regional scenario today, the two countries have to play a benign role in promoting stability and prosperity in the region and the world at large. The need for mutual cooperation is driving the two countries to get closer. The growing cooperation on the basis of each country's interests and needs reinforces the traditional values of the two countries. In addition, fruitful cultural interactions dating back to first century A.D. and people-to-people contacts have served as positive factors to promote current political, diplomatic, economic, trade, defence and security relations. The potential for cooperation between the two sides needs to be assessed constantly, updated and renewed.

There is no dearth of works on Vietnam-India relations in recent years, but they do not seem to have highlighted significant trends in India-Vietnam special relationship. Therefore, an attempt has been made to bring out this volume entitled *India-Vietnam Relations: Friendship to Partnership*.

The papers in this book have touched upon all areas of Vietnam-India relations, from the traditional and historical connections to modern cooperation in politics, economy, security and other areas. This book provides critical analysis of relations. Two countries are having great opportunities to cooperate and the prospects of the relations are very bright.

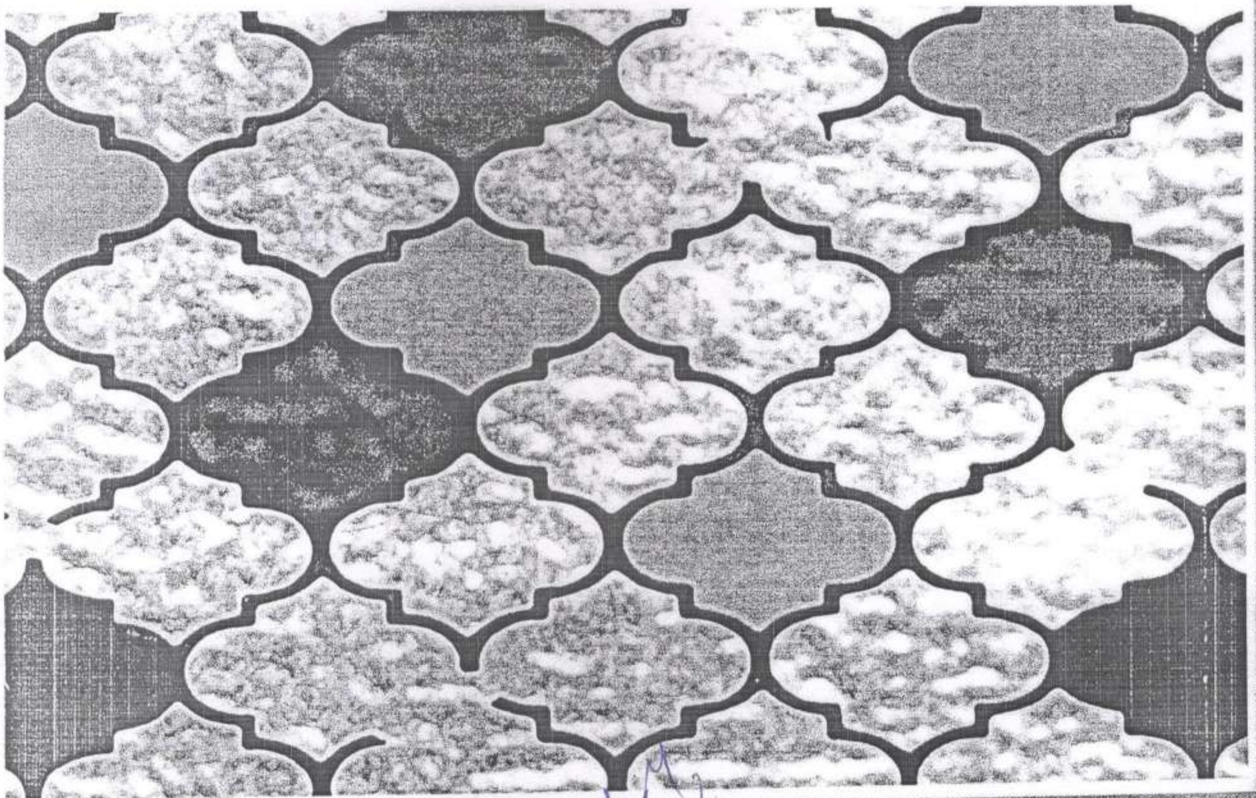
This book is made possible with the collaboration between two institutions – the Institute for Indian and Southwest Asian Studies, Hanoi, and the Centre for Southeast Asian and Pacific Studies, Sri Venkateswara University, Tirupati. The scholarly contributions to this compendium from both countries not only provide a comprehensive perspective in understanding bilateral relations but also offer insights into institutional linkages between the two friendly nations.

Both the editors take this opportunity to place on record their sincere thanks to the Centre for Southeast Asian and Pacific Studies, Sri Venkateswara University and the Institute for Indian and Southwest Asian Studies, Hanoi which made this joint effort fruitful and rewarding. The editors would also like to express their gratitude to the scholars from India and Vietnam for their splendid contribution which enriched the value of this work. Narendra Publishing House, New Delhi, deserves special mention for paying special attention to printing and designing of this volume.

Jayachandra Reddy G
Nguyen Xuan Trung

الهند والعرب

ثقافة وحضارة



د. محمد آفتاب أحمد - د. محمد قاسم العادل

Self Attested
Md. Quamruddin
08.10.2022

بيانات عن الكتاب

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Self Attested Md. Qasim 08.10.2022

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ISBN : 978-81-950288-0-1

Printed by:
Markazi Publications
S-17/4, Jogabai Ext. Jamia Nagar, New Delhi -25
Cont.: +91-9811794822/21
E-mail: markazipublication@gmail.com

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الدكتور سيد محمد طارق الندوي يشتغل كأستاذ مساعد في قسم اللغة العربية بكلية ذاكر حسين دلهي لجامعة دلهي، الهند. وله كتاب باللغة العربية طبع في عام 2013م باسم "أدب الأطفال العربي في الهند". وهو يهتم بدراسة أدب الطفل باللغات الهندية للكتاب الهنود؛ وتم نشر مقالاته حول القصص الإنجليزية للقاص الهندي رسكن بوند، واستعراض أعمال الكتاب الهنود الآخرين الخاصة بالنشء في مجلات أدبية وعربية دولية. وإضافة إلى هذا قدم د. طارق مقالات أكاديمية في المؤتمرات والندوات العلمية الهندية والدولية. nadvitariq@gmail.com

الدكتور محمد قمر الدين أستاذ مساعد في قسم اللغة العربية بكلية ذاكر حسين دلهي (جامعة دلهي)، الهند، وله مؤلفات منها كتابه في قواعد الترجمة من اللغة العربية إلى الإنجليزية وبالعكس باسم "Translation Made Easy"، إلى جانب العديد من البحوث والمقالات المنشورة في المجلات والدوريات الوطنية والدولية باللغة العربية والانجليزية والأردية حول مواضيع تتعلق باللغة العربية وآدابها، والترجمة، وعلوم القرآن والدراسات الإسلامية وما إلى ذلك. كما أنه شارك في المؤتمرات والندوات العلمية الأكاديمية وورشات العمل والدورات التدريبية الوطنية والدولية. qamar.arbeng@gmail.com

الدراسات الإسلامية في الهند

الهند والهنود في كتابات العرب

الترجمات الإنجليزية لمعاني القرآن الكريم في الهند

Self Attest
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08.10.2022

الدكتور محمد قمر الدين

الملخص:

القرآن الكريم كتاب إلهي، أنزله الله تعالى بلسان عربي مبين على رسوله المبعوث إلى الناس كله، ليبين لهم ما نُزِّل إليهم، فبينه هو وفسره، وحذا حذوه أصحابه ومن تبعهم. وهو كتاب الهداية وفيه الرسالة للبشرية جمعاء. وكما أن القرآن الكريم مصدر رئيس للدين الإسلامي ومرجع هام للغة العربية وآدابها، إنه مازال محورَ اهتمام بالغ للعلماء والباحثين في كل عصر ومصر، فقد اشتغلوا بدراسته والتدبر فيه، وكرّسوا حياتهم للبحث عما يوجد فيه من كثرة المعاني والأحكام الدينية والمحاسن اللغوية والأدبية، وذلك ما أدى إلى ظهور آلاف التفاسير، والترجمات المتنوعة، والكتب الأخرى في علوم القرآن في لغات العالم. وللهند دور بارز في كل فرع من فروع المعرفة التي تساعد على فهم القرآن الكريم، وبالأخص لها حظ كبير في حقل ترجمة معاني القرآن الكريم حيث تم نقلها إلى أكثر لغاتها، بما في ذلك اللغة الأردية والفارسية والهندية والبنغالية والغجراتية والكشميرية والسندية والبنجابية والتيلجو وغيرها. وترجمة معاني القرآن الكريم إلى اللغة الإنجليزية من أبرز ما ساهمته الهند في باب الترجمة.

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ند و إيران نموذجا"،
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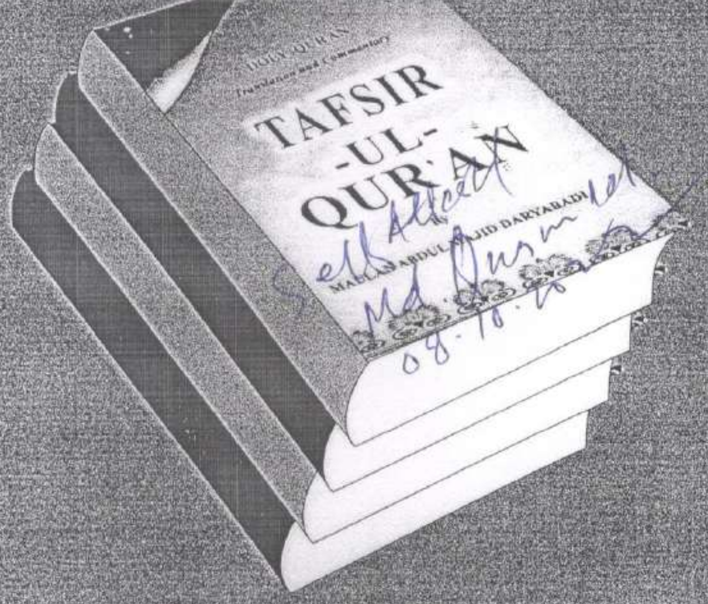
ABDUL MAJID DARYABADI'S
TAFSĪR-UL-QUR'ĀN
A CRITICAL STUDY



Edited by
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K. A. Nizami Centre for Quranic Studies
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First Published 2021

ISBN: 978-93-90167-79-1

Price: ₹ 600/-

Self Attested
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08.10.2022

K. A. NIZAMI CENTRE FOR QURANIC STUDIES
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Published by
Brown Book Publications Pvt. Ltd.
Opposite Blind School, Quila Road,
Shamshad Market, Aligarh (U.P.) 202002
Mobile: +91 9818897975
E-mail:brownbookpublications@gmail.com
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Abdul Majid Daryabadi's English *Tafsīr-ul-Qur'ān*: An Analytical Study

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Md. Quamruddin*

Abstract: The *Tafsīr-ul-Qur'ān* (Translation and Commentary of the Holy Qur'ān) by Abdul Majid Daryabadi (1892-1977)[1] is the first English work of its type which re presents the *Ahl al-Sunnah wa al-Jama'ah;* the mainstream Muslims' viewpoint. It is one of the several works of Daryabadi which are widely acclaimed. It is a literal and faithful rendering in 'tolerable' English. The commentary is in detail to satisfy the readers. It contains notes and comments on comparative religions; especially it presents a contrastive study of the Holy Qur'ān with the Bible. The historical, geographical and eschatological comments are its distinctive feature. The work is mainly based on the classical interpretations and on, to some extent, the modern findings of different sciences, related to the things mentioned in the Holy Qur'ān.

Keywords: *Tafsīr-ul-Qur'ān,* Abdul Majid Daryabadi, Qur'ān Translation, *Tafsīr, Ahl al-Sunnah wa al-Jama'ah*

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Reconfiguring the Historical Landscape of Rajasthan

Essays for G.S.L. Devra

Edited by
Mayank Kumar
Suraj Bhan Bharadwaj
Rameshwar Prasad Bahuguna
Sangeeta Sharma

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First Published 2021

ISBN 978-93-5002-693-9

Published by
AAKAR BOOKS
28 E Pocket IV, Mayur Vihar Phase I
Delhi 110 091 India
aakarbooks@gmail.com

Laser Typeset at
Arpit Printographers, Delhi

Printed at
Sapra Brothers, Noida

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Celebrating the City: Kolkata in Indian Literature: Proceedings of the Symposium on Celebrating the City: Representations of Kolkata in Indian Literature, organised by Sahitya Akademi in collaboration with the Centre for Translation of Indian Literatures, Jadavpur University on 9 January 2020, in Kolkata, edited by Sayantan Dasgupta. Sahitya Akademi, New Delhi (2021). ₹ 270.

Sayantan Dasgupta (b. 1974): Editor

Genre: Essays/Literary Criticism

Published by Sahitya Akademi
First Published : 2021

ISBN: 978-93-5548-111-5

₹ 270

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Cover artwork by Camellia Paul, Kolkata
Typeset by Lalit Mohan, New Delhi.
Printed by G.S. Offset, Delhi.

Website: http://www.sahitya-akademi.gov.in

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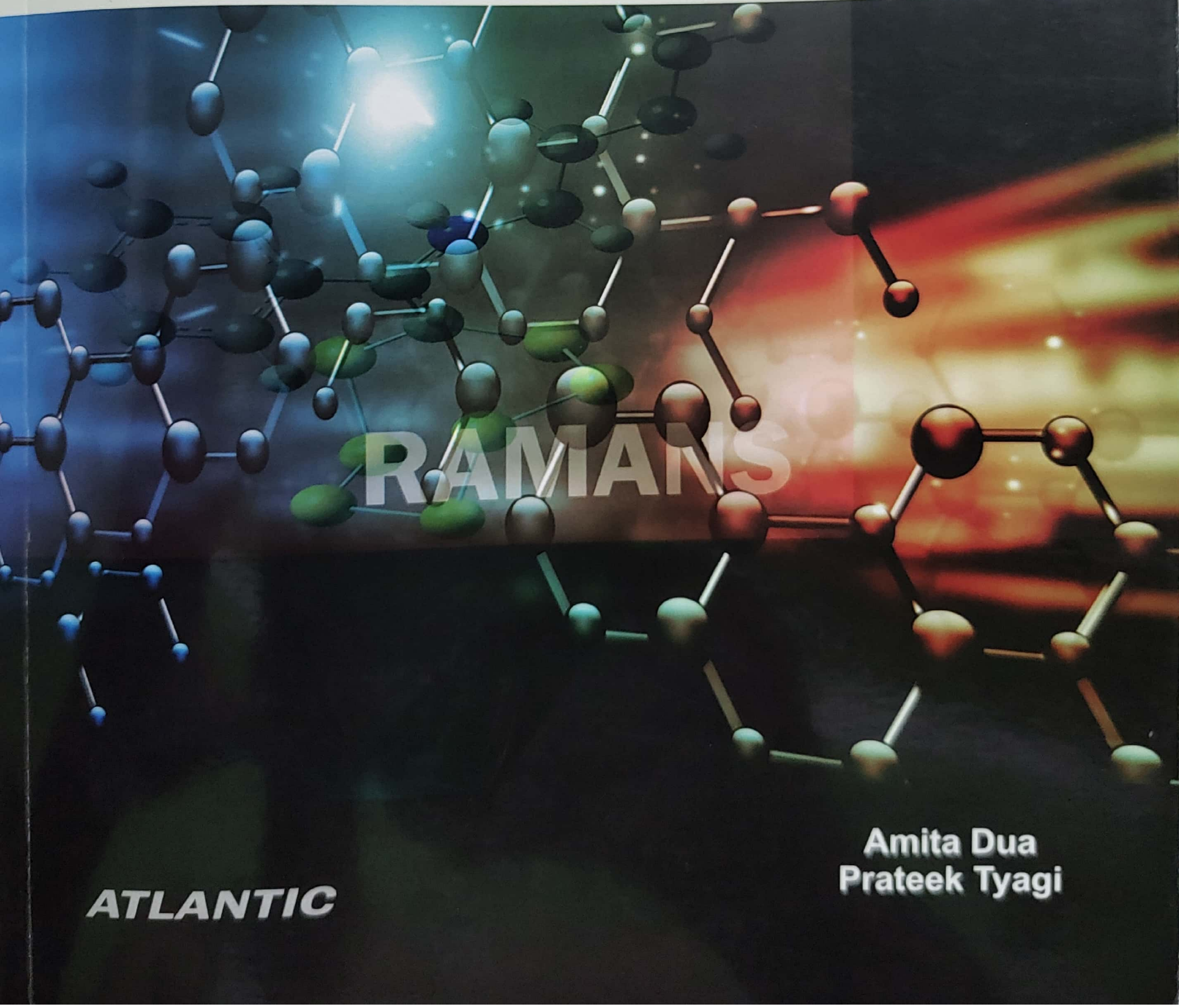

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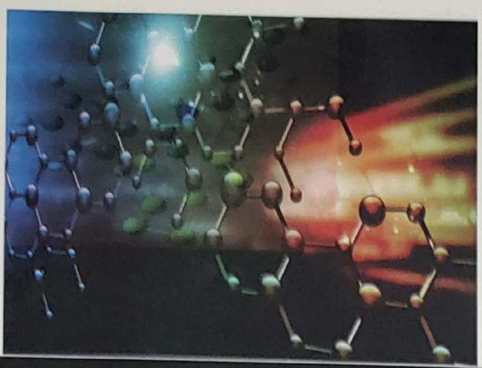

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Quantum to Spectrum

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PUBLISHERS & DISTRIBUTORS (P) LTD
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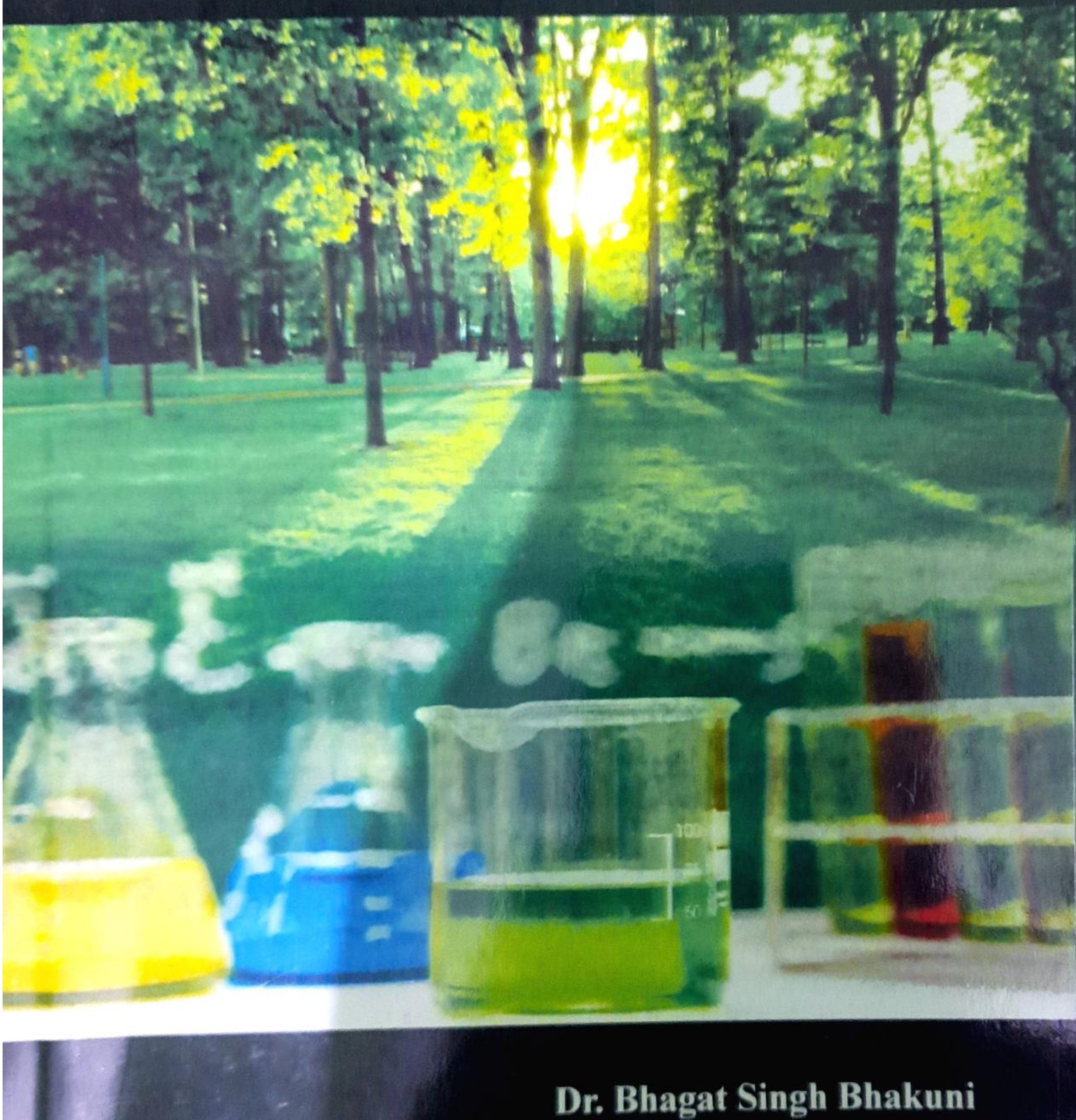

Dr. Bhagat Singh Bhakuni
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Dr. Bhagat Singh Bhakuni was born in Almora, Uttrakhand in 1987. He did B.Sc. Hons Chemistry and M.Sc. Chemistry from Kirori Mal College of University of Delhi from 2004-2009. Subsequently, he obtained Ph.D. Chemistry from Indian Institute of Science Education and Research, Bhopal in 2014, under supervision of Prof. Sangit Kumar (Head, Department of Chemistry). He joined Kirori Mal College as faculty member after brief post doc stint at Indian Institute of Technology Mandi in 2015. He obtained post graduate diploma in intellectual property rights (PGDIPR) and pharmaceutical management (PGDPSM) from IGNOU. He also had post graduate certificate in forensic science (fingerprinting and documentation) and geoinformatics (PGCGI) from University of Delhi and IGNOU respectively. He had certificate in hyper spectral imaging from Indian Institute of Remote Sensing (ISRO) Dehradun. His research work are part of several international books at M.Sc. and Ph.D. level. He is life member of Indian Science Congress (ISC) and Indian Society of Analytical Chemist (ISAS). His research interest are in organic, inorganic, environmental, and biochemistry.

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Mob. 9810766022, 9810766722
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Price: Rs. 395.00

ISBN 819514928-6

9788195149285

International Conference on

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1-2 April, 2022 | New Delhi, India

ABSTRACTS

Edited By
Dr. Ravi Kant
Ms. Leela Gautam
Dr. Ritu Mathur
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Dr. Manohar Lal

Jointly organized by

Zakir Husain Delhi College
University of Delhi

&

Indian Society of Analytical Scientists
(ISAS), Delhi Chapter

... interest. This ... to create or eliminate any character, for instance. ... of DNA along with the enzyme Cas system work to cleave the DNA as molecular scissors and hence are extremely consistent and adjustable for several applications. The process of genetic engineering has been made trouble-free and lesser labor- intensive with its help. A novel incipient area called the synthetic genomics has opened the doors for the prospects in creation of synthetic genome for producing artificial cell. The present study involves the comprehension of the use of CRISPR tools from the basics and advancements and the production of biomolecules by the CRISPR approach.

Keywords: CRISPR/Cas Systems; Genetic Engineering; Gene Knock – ins

Nano-Liquid Chromatographic Enantioseparation of Some Bioactive Pharmaceuticals

Manohar Lal[1], Prateek Tyagi[1], Usha Bansal[1] and Gajendra Singh[2]
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Nano-Liquid Chromatography (LC) is a miniaturised version of HPLC in which analytes are separated in capillary columns with a tiny diameter (< 100 µm i.d.). Low-flow mobile phase (50–800 nL/min) is injected into the column. Nano-LC is a chemical analysis method that offers more possibilities than traditional LC. Miniaturized technologies such as nano-LC, microchip devices, and nano-capillary electrophoresis reduce reagent use and waste creation. Furthermore, low analyte levels, particularly in biological samples, encourage the development of more sensitive techniques; when combined with mass spectrometry, nano-LC has the potential to become a vital tool for routine biomolecule analysis. This report examines the fundamentals of nano-LC analytical instrumentation, as well as practical issues and the key differences between miniaturised and conventional instruments. Some theoretical elements of nano-LC are examined in order to better understand both its promise and its main limits. Recent pharmaceutical and medicinal uses of this separation technology are also discussed, demonstrating nano-suitability LC's for complex matrices, particularly for proteomic analysis. Miniaturized separation techniques have evolved as greener alternatives to existing separation technologies. Nano-LC provides several advantages, including: (i) a significant reduction in mobile and stationary phase consumption, including hazardous reagents; (ii) the tiny sample size required; (iii) high efficiency separations while keeping the same retention behaviour; and (iv) facile spectrometry linkage.

Keywords: Nano- Liquid Chromatography (LC), HPLC, Miniaturized, nano-capillary electrophoresis, eco-friendly.

Energy

Energy

Crises, Challenges and Solutions

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WILEY Blackwell

This edition first published 2022

Registered Offices
John Wiley & Sons, Inc., 111 River Street, Hoboken, NJ 07030, USA
John Wiley & Sons Ltd, The Atrium, Southern Gate, Chichester, West Sussex, PO19 8SQ, UK

Editorial Office
9600 Garsington Road, Oxford, OX4 2DQ, UK

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Library of Congress Cataloging-in-Publication Data

Names: Singh, Pardeep, editor. | Singh, Suruchi, 1987– editor. | Kumar, Gaurav, 1984– editor. | Baweja, Pooja, 1977– editor.
Title: Energy : crises, challenges and solutions / edited by Pardeep Singh, Suruchi Singh, Gaurav Kumar, Pooja Baweja.
Description: Hoboken, NJ : Wiley-Blackwell, 2022. | Includes bibliographical references and index.
Identifiers: LCCN 2021007246 (print) | LCCN 2021007247 (ebook) | ISBN 9781119741442 (cloth) | ISBN 9781119741510 (adobe pdf) | ISBN 9781119741558 (epub)
Subjects: LCSH: Renewable energy sources. | Energy development. | Energy policy.
Classification: LCC TJ808 .E565 2022 (print) | LCC TJ808 (ebook) | DDC 333.79/4–dc23
LC record available at https://lccn.loc.gov/2021007246
LC ebook record available at https://lccn.loc.gov/2021007247

Cover Design: Wiley
Cover Image: © Funny Solution Studio/Shutterstock

Set in 9.5/12.5pt STIXTwoText by Straive, Pondicherry, India

10 9 8 7 6 5 4 3 2 1

Contents

Preface

Energy is an indispensable component of every aspect of development, wealth, health, nutrition, infrastructure, and education. Energy is a necessary element in development that should be a fundamental right. Many development indicators are strongly related to per-capita energy consumption. The economic development of many countries has come at the cost of the environment. It should not be presumed that a reconciliation of the two is not possible. There is a need to take enhanced global actions to address emission problems.

Fossil fuel is the most conventional energy source, but its usage is full of dichotomy as its utilization has increased during economic development, but that also increased greenhouse gas emissions. Also, fossil fuel conservation will include finding a way to tap into the Earth's supply so that the commonly used oil fields are not drained completely. What will pave the way for natural recovery? The depletion also creates an enormous destructive waste product that then impacts the rest of life. The nexus concept is the interconnection between energy, water, food, land, and climate. Such interconnections enable us to address trade-offs and seek synergies among them. Putting pressure on one component will affect other components as well. Energy, water, food, land, and climate are essential resources of our natural environment and support our quality of life. Competition between these resources is increasing globally and is exacerbated by climate change. Improving resilience and securing resource availability would require improving resource-use efficiency.

Many policies and programmes are announced nationally and internationally to replace the conventional mode and emphasize the conservation of fossil fuels and reuse of exhausted energy, so a gap in implications and outcomes can be broadly traced by comparing the data.

The book 'Energy Crises, Challenges, and Solutions' aims to highlight problems and solutions related to conventional energy utilization, formation, and multitudes of ecological impacts and tools for the conservation of fossil fuels. The book also discusses modern energy services as one of the sustainable development goals and how the pressure on resource energy disturbs the natural flows. The book covers holistic issues related to energy and its contribution in triggering climate change and replenishing fossil fuel, emphasizing fossil fuel conservation and thus nature recovery. The compilation also highlights direct and indirect implications on different sectors. Many policies and legislations have been documented, but still, energy-related problems cannot be checked. This book helps identify these gaps, especially in the developed region. It benefits researchers and all other sectors and stakeholders, students, industries, and governmental agencies directly or indirectly associated with energy research.

We are highly delighted and express our gratitude to all the authors for their outstanding cooperation towards the compilation of this book. We also extend our sincere thanks to all the reviewers for their valuable suggestions and comments, which have helped us tremendously prepare this book. We also thank Wiley Publication, Andrew, Rosie, and Shiji for their generous support and efforts.

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ISBN: 978-81-950918-6-7

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মোবাইল: ৮৬৪১৯৩৭৩৫৬, ৯৮৩৬৯২৯৫৮০
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₹ ৩৫০ টাকা

श्रीप्रभु pratibha Part-50&51, January-June-2021, pg.-05-11
R.N.I–UPHIN/2008/30056, ISSN-0974-522X, JIF-3.817

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शोध लेख सार– प्राचीन असम में प्राप्त अभिलेखों की समृद्ध परम्परा रही है ये 5वीं शताब्दी के आरम्भ से लेकर 12वीं शताब्दी के प्रथम पूर्वार्ध तक के प्राप्त हैं जो साहित्यिक छटा से परिपूर्ण हैं। इन अभिलेखों की सरल, सरस, अलंकारिक व काव्यमय शैली तथा संस्कृत परिमार्जित व प्रवाहपूर्ण भाषा का समीक्षत्मक विश्लेषण प्रस्तुत करने का प्रयास किया गया है।

मुख्य बिन्दु– पाण्डुलिपियाँ, मुद्राएँ, सिक्के एवं अभिलेख।

तथ्य एवं तथ्य विश्लेषण– असम के पांचवी शताब्दी के आरम्भ से लेकर बारहवीं शताब्दी के प्रथम पूर्वार्ध तक के प्राप्त अभिलेखों में संस्कृत साहित्य के उत्कृष्ट उदाहरण वर्णित है जो साहित्य छटा से कितने परिपूर्ण है।

शोध प्रविधि– प्रस्तुत शोध में वर्णनात्मक एवं समीक्षात्मक शोध पद्धति का प्रयोग किया गया है।

प्रस्तावना– अभिलेख समकालीन इतिहास की रचना के मुख्य स्रोत व मानव संस्कृति की विशिष्ट परम्परा के द्योतक है। इतिहास के पुनर्निमाण में अभिलेखों से उपादेय तत्वों की उपलब्धि होती है। इनमें पाण्डुलिपियाँ, मुद्राएँ, सिक्के, अभिलेख प्रमुख हैं। अभिलेखों में घटनाओं का कालक्रम, महत्वपूर्ण राज वंशों का उदय, वैभव, वंशावली, तात्विक सामाजिक, आर्थिक, राजनैतिक ऐतिहासिक तथा साहित्यिक पक्षों को उद्घाटित कर इतिहास के पुनर्निमाण में सहायता प्रदान करते हैं।

अभिलेखों की परम्परा में अनेक साहित्यपरक अभिलेख भी मिलते हैं। प्राचीनकाल से ही अलंकृत गद्य व पद्य शैली में निबद्ध अभिलेख उदाहरणार्थ रूद्रदामा का गिरनार शिलाभिलेख, समुद्रगुप्त– इलाहाबाद स्तम्भलेख, पट्टवाय श्रेणी का मन्दसौर आदि संस्कृत साहित्य परम्परा में अपने-अपने समय के नैरन्तरय को प्रस्तुत करते हैं।

प्राचीन असम में प्राप्त अभिलेखों की समृद्ध परम्परा रही है ये 5वीं शताब्दी के आरम्भ से लेकर 12वीं शताब्दी के प्रथम पूर्वार्ध तक के प्राप्त हैं जो साहित्यिक छटा से परिपूर्ण हैं। इन अभिलेखों की शैली सरल, सरस, अलंकारिक व काव्यमय है। भाषा संस्कृत परिमार्जित व प्रवाहपूर्ण है। उपमालंकार सर्वाधिक चमत्कारपूर्ण अर्थालंकार है जो विविध हाव-भावों के साथ काव्य के सौन्दर्य में वृद्धि करता है। आसाम के

लेखों में भी पूर्णोपमा व लुप्तोपमा दोनों भेदों का प्रचुर प्रयोग मिलता है। श्रवणमात्र से ही सादृश्य की प्रतीति कराने वाली श्रोती पूर्णोपमा के अनेक उदाहरण द्रष्टव्य हैं। भास्कर वर्मन के दुबी ताम्रपट्ट अभिलेख के 'व्यालरत्नोपसेषितः' अंश में पूर्णोपमा अलंकार है इस में व्याल का अर्थ सर्प है। परन्तु यहाँ इस का अर्थ समुद्र लिया है अगाध, स्वच्छ गंभीर शीतल, सर्प व रत्नों से युक्त समुद्र के समान वह राजा भी था।[1] ''यमीगंगा संगोच्छलित जलकल्लोलवहलः'' भाग में समास युक्त उपमा द्रष्टव्य है।[2] वनमाल के तेजपुर ताम्रपट्ट अभिलेख में ''दिवाकरायितं'', भाग में उपमा है। जिस प्रकार सूर्य अपनी रोशनी से अंधकार नष्ट करता है उसी प्रकार राजा ने युद्ध क्षेत्र में शत्रुओं को नष्ट किया[3] अन्य अनेक स्थानों पर बड़े ही सुंदर ढंग से राजा की प्रसिद्धि की तुलना चन्द्रमा तथा महान पुरुषों से की है।[4] 'तारकाप्रकरायितं[5]' अंश में क्यण्प्रत्यय के कारण लुप्तोपमा है। शिव के सिर पर धारण किया हुआ जल जो कि तारकसमूह के समान प्रतीत हो रहा है तथा रेचक वायु द्वारा इधर उधर फैलाया जा रहा है। ऐसा गंगा का जल तुम्हें पवित्र करे इसमें वाचक शब्द इव छिपा हुआ है गंगा का जल-उपमेय, तारक-उपमान है। इसी प्रकार 'धवलीकृत शब्द में रूपक की छटा दर्शनीय है इस में उपमान व उपमेय के गुणों का साम्य होने से इस में राजा व चन्द्रमा दोनों का आरोप है[6] इसी प्रकार 'घटाध्वान्तोरूसंहति' शब्द में सूर्य व राजा दोनों का आरोप है यह श्लिष्ट शब्द निबंधन परम्परित रूपक राजा में सूर्यत्व के आरोप का कारण है[7] 'सुरगुरुरिप वाप रैः, में उत्प्रेक्षा द्वारा सुरगुरु की कल्पना राजा में की है[8] 'कान्तामुखैबहुविधाविव, भाग में वाच्योत्प्रेक्षा द्वारा प्रस्तुत स्त्री मुख की संभावना अप्रस्तुत चन्द्रमा तारे से की है।[9]

अनेक अतिश्योक्ति पूर्ण वर्णन भी काफी मात्रा में पाए जाते हैं। उदाहरण के लिए भास्करवर्मन के दुबी ताम्रपट्ट अभिलेख में एक स्थान पर अनेक सामन्तों के मणिजडित मस्तक झुकने से जिस के चरण स्थल कमल की शोभा को धारण किए हुए हैं तथा जिस ने अपनी आत्मा को जीत लिया है।[10]

भास्करवर्मन के लेख में एक स्थान पर 'जयति' का प्रयोग है जिस का अर्थ प्रणाम Salute किया गया है। आचार्य मम्मट ने काव्य प्रकाश के मंगलाचरण में इसका प्रयोग किया है। धर्म को परहित मूर्ति बताया है दूसरों के लिए परोपकार करने वाला। पी.सी. चौधुरी के अनुसार इन शब्दों के द्वारा शिव के प्रति भक्ति दिखाई है।[11] इसी प्रकार राजा को चन्द्रमा से सुंदर व कलंक रहित बताते हुए 'श्री मृगांक', व्यतिरेक अलंकार द्वारा बताया है।[12]

साहित्यिक दृष्टि से सुंदर शैली में निबद्ध अलंकारिक छटा से परिपूर्ण रत्न पाल के बरगाँव लेख से ज्ञात होता है कि लेखक को शब्दकोष का ज्ञान तथा व्याकरण पर पूर्ण अधिकार था। दंडी, सुबन्धु व बाणभट्ट का स्पष्ट प्रभाव दृष्टिगोचर होता है उदाहरण- तत्रा च जड़ता हारयष्टिषु न इन्द्रियेषु, चंचलता हरिषु न मानसेषु,

भघ्गुरता भ्रूविभ्रमेषु न प्रतिपखेषु, सोप सर्म्गता धातुषु न प्रजासु,

इस में परिसंख्या अलंकार द्वारा सामान्य जन-जीवन का अत्यंत सरल व काव्यात्मक वर्णन किया गया है[13] अर्थात् दुर्जय शहर में जडता हारों में थी लोगों में नहीं, चंचलता बंदरों में थी लोगों की बुद्धि में नहीं।

रत्नपाल के बरगाँव लेख के शार्दुलविक्रिडित छंद में निबद्ध ''सोवश्रीव, शब्द से व्याकरण पर अधिकार का पता चलता है। पाणिनी (7-3-3) के अनुसार इसका अर्थ ऐसा घोड़ा जो उत्तम गुण युक्त युग्म से उत्पन्न है।[14] महाकवि दण्डी के काव्यादर्श से साम्य रखता हुआ वर्णन भास्कर वर्मन के दुबी ताम्रपट्ट में मिलता है। अलंकृतैः सुललितपदं सर्व्वमार्ग्गकवित्वं मार्गों का उल्लेख का वर्णन आता है।

दुबी ताम्रपट्ट लेख में ही सुन्दरियों की सरल व सुंदर स्वाभाषिक वर्णन का उदात्त अलंकार में वर्णन है- 'समदसुन्दरीस्मितसुधाध्वलितं'[15] गोपाल वर्मन के लेख में 'राज हंसैगगनतलगाय'[16] भाग में अभिजात्य गुण द्रष्टव्य है आसमान राज हंसों से ढक गया जो दो वर्णों से सुशोभित है'' श्वेत और रक्त वर्ण। इस में रक्तवर्ण परिवार के अभिजात्य गुण का तथा श्वेतवर्ण प्रसिद्धि का द्योतक है उदारता, माधुर्य, शौर्य, प्रसाद आदि गुणों में निबद्ध मालिनी छंद भावानुकूल व विषयानुवर्ती है।

होमधूमवलयेवियद्गतेय ज्वनांद्धतुषुकालिकाभ्रमात्।
यत्राडम्बरकाण्डताण्डवेतनुरून्मुखशिखाशिखाण्डिनः।।[17]

अर्थात् ब्राह्मणों के द्वारा किया हुआ विजयी यज्ञ का धुआ आकाश में चारो और फैल गया है जिसे मयूरों ने काले बादल समझकर नृत्य करना आरम्भ कर दिया यहाँ पदलालित्य दर्शनीय है।

रत्नपाल के सुवाकुची लेख में शब्दशक्ति मूल का सुंदर उदाहरण दृष्टव्य है।[18] इस में भगवान कृष्ण व ब्राह्मण वासुदेव की समानताश्लिष्ट शब्दों में बताई है वासुदेवराजा भट्टबलदेव का पुत्र है। यहाँ वासुदेव का अर्थ भगवान कृष्ण तथा प्रविकसित-कमलनयन का अर्थ बलदेव पुत्र अर्थ में खिले हुए कमल के समान नेत्र वाला, भगवान कृष्ण के अर्थ में 'पुण्डरीकाक्ष' कृष्ण के दूसरे नाम का द्योतक है।

भास्करवर्मन के निधनपुर लेख में 'पार्थिवविन्दारकों' के समान रामायण के किष्किन्धाकाण्ड, मनुसंहिता तथा समुद्रगुप्त के इलाहाबाद लेख में वर्णन साम्य प्रतीत

होता है। ताम्बुल शब्द का आसाम के सांस्कृतिक जीवन में बहुत महत्वपूर्ण स्थान है उत्तरवराविललेख का वर्णन मेघदूत से साम्य रखता प्रतीत होता है-

तम्बूलवल्लीप रिणद्वपुगं......... निवेशितेलं।।5।। पृ 124

ताम्बूल वल्लीप रिणद्वपूगाश्वेलालतालिंगित चन्दनासु।। मेघदूत 6.64

इसी अभिलेख के अनेक वर्णन प्रसंग रघुवंश के वर्णनों से मेल खाते हैं तथा महाकवि कालिदास को वैदर्भी शैली व भावों का स्पष्ट प्रभाव स्थान-स्थान पर दिखाई देता है। लेखों में कल्पनाशक्ति का सहारा भी लिया गया है। भास्कर वर्मन के लेख में भास्करवर्मा की वीरता की तुलना मृग की ऊँची कूद से की है।

इन्द्रपाल के गोदावरी लेख के मंगलाचरण का श्लोक मुद्राराक्षस के मंगलाचरण से मेल खाता प्रतीत होता है। के. एल. बरूआ के अनुसार विशाखादत्त ने यह श्लोक अवन्तिवर्मन के शासनकाल में लिखा प्रतीत होता है। इस में भगवान शिव के मस्तक पर विराजमान गंगा को देखकर पार्वती को ईर्ष्या हो रही है और वह कहती हैं मैं गंगा को छोड़कर खेल में जीती हुई सब वस्तुएँ वापस करती हूँ। यह वर्णन साम्य शार्दूलविक्रिडित छंद में निबद्ध है।

इस प्रकार असम के अभिलेखों में संस्कृत साहित्य के उत्कृष्ट उदाहरण वर्णित है ये अभिलेख पांचवी शताब्दी के आरम्भ से लेकर बारहवीं शताब्दी के प्रथम पूर्वार्ध तक के प्राप्त होते हैं जो साहित्य छटा से परिपूर्ण है। कहीं पर व्याकरणात्मक त्रुटियाँ होते हुए भी वर्णन सरल, अलंकारिक, छंदोबद्ध व काव्य मय है शब्दालंकारों का प्रयोग अतिश्योक्ति, विरोधाभास, तुल्योगिता, व्यतिरेक, विषम, परिसंख्यण, अनुप्रास संदेह आदि अलंकारों का प्रयोग किया गया है। उपमामूलक अलंकार काफी मात्रा में विद्यमान ही है इस समय के साहित्यिक गद्यांश व पद्यांश कालिदास, दण्डी, वाण आदि के उच्च कोटि के गद्य के मध्य एक कडी का काम करते हैं भाषा साहित्यिक दृष्टि से समृद्ध व विकास की ओर अग्रसर थी। इस प्रकार आसाम के अभिलेख संस्कृत साहित्य की समृद्ध परम्परा के द्योतक है।

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9- Ibid – V-4, p. 258

10. प्रणतानेक सामन्तशिरोमणि शिखारूपणौ स्थलपद्मादी यन्धत्त पादौ यस्य (जि) तात्मनः ।।48।।] V-4, p. 258, Sharma, Mukund Madhvi :Inscriptions of Ancient Assam, p. 16

11.जयति जगदेकबन्धुर्लोकद्वितय स्यसम्प दो हेतुः। परहितमूर्तिरहष्ट फलानुमेय स्थिति धर्म्मः।।3।।Ins9, p.4

12. नृपादकलघ्रक श्री मृगाघ्रकोभूत ।।17।। p. 42

13. Ibid – L-40-41, p. 158

14- Ibid – Ins – 13, V-1, p. 154-155

15- Ibid – V-14, p. 19, Ins – 3

16- Ibid – Ins – 13, L-31-32, p. 154

17- Ibid – V-10, p. 259

18. आसीत् प्रतिहतनरकोबहुविबुधवन्धमान चरणयुग्मः।
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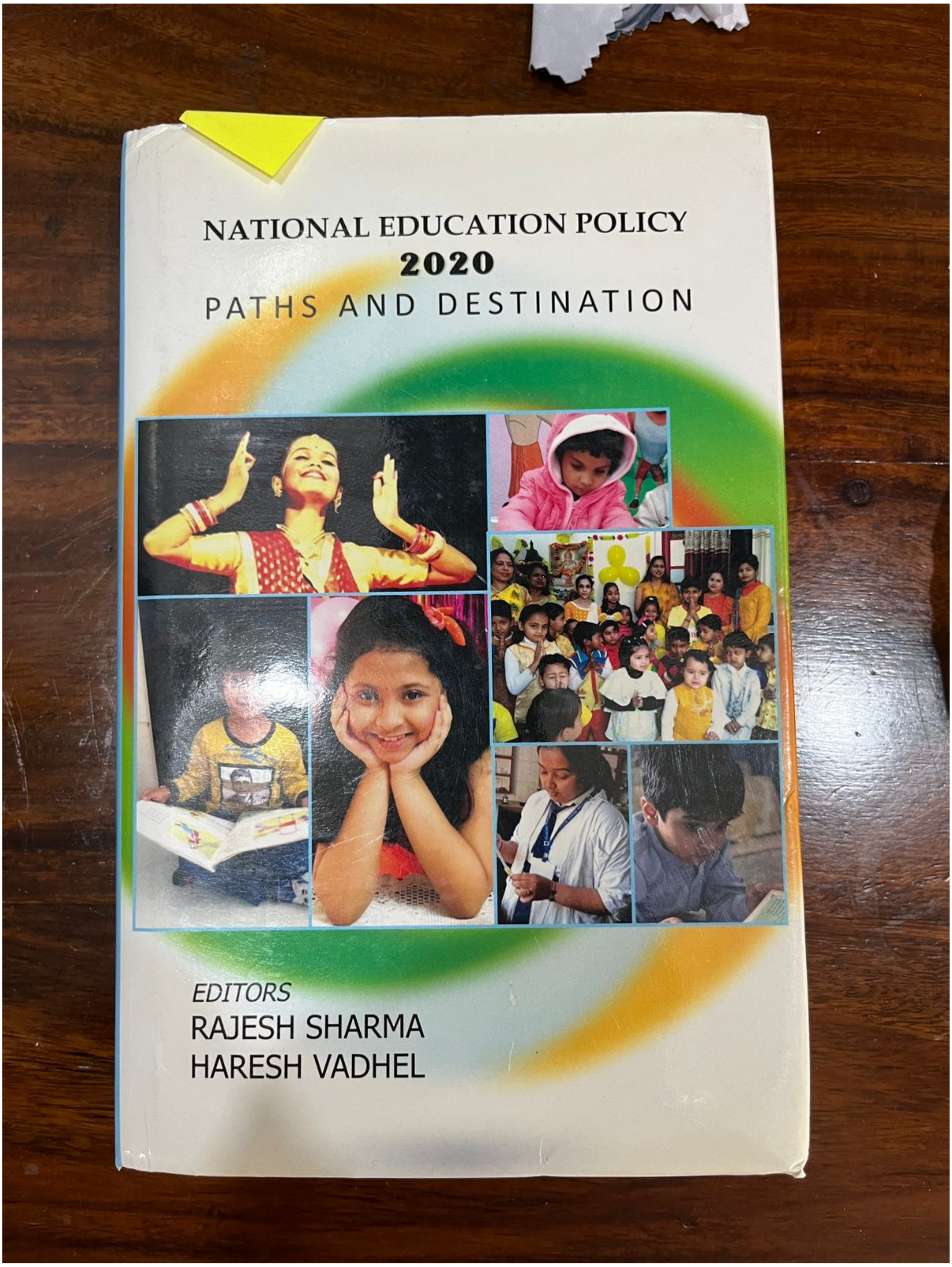
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PATHS AND DESTINATION
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11 जेंडर

मानसी मिश्रा

प्रस्तावना

इस बात से इंकार नहीं किया जा सकता कि आज जेंडर का मुद्दा जाति अथवा वर्ग जितना ही महत्त्वपूर्ण है। महिलावादी अध्येयताओं को इस बात का श्रेय देना चाहिए कि वे इस मुद्दे को बौद्धिक और अकादमिक दुनिया में लेकर आए। परंतु लिंग शब्द की जो परिभाषा आज दी जाती है, उसके वर्तमान रूप की परिणति आसान नहीं रही है। शब्दकोशों में प्रायः *सेक्स* और जेंडर, इन दोनों शब्दों को एक दूसरे के पर्याय के रूप में दर्शाया जाता है जबकि नारीवादी विचारक पहले ही इन दोनों को दो भिन्न अवधारणात्मक शब्दों के रूप में व्यक्त कर चुके हैं। सन 1972 में प्रकाशित, अपनी पुस्तक *सेक्स, जेंडर एंड सोसाइटी* में येन ओकली ने इस कथन को लोकप्रिय बनाया कि, 'यौन (sex) जैविक प्रकृति और लिंग (जेंडर) संस्कृति (सामाजिक प्रकृति) को व्यक्त करता है' (ड्यूकेन, 1994, 228)। इसका तात्पर्य है की हमारा जन्म *सेक्स* के रूप में होता है, लेकिन हम जिस सांस्कृतिक परिवेश में रहते हैं वहाँ के समाजीकरण की प्रक्रिया द्वारा हम मर्द और औरत (लिंग) के रूप में परिणत होते हैं। अतः *सेक्स* यह बताता है कि इंसान महिला है अथवा पुरुष है जबकि जेंडर स्त्रीत्व (femininity) अथवा मर्दानगी (masculinity) को व्यक्त करता है। स्त्री और पुरुष का अर्थ तो सर्वव्यापी है लेकिन स्त्रीत्व और पुरुषत्व का अर्थ विभिन्न संस्कृतियों के कारण प्रत्येक स्थान पर भिन्न है। कभी-कभी जेंडर का उपयोग भिन्न *सेक्स* के लोगों के बीच संबंध को निरूपित करने के लिए किया जाता है तो कभी इसका अर्थ महिलाओं की भूमिका, स्थिति और अनुभव से संबंधित होता है (ड्यूकेन, 1994)।

सेक्स/जेंडर : नारीवादी अध्ययन

नारीवादी अध्ययनों में इस बात पर विशेष बल दिया गया है कि जैविक बनावट में अंतर के आधार पर महिला और पुरुष की समाज में भिन्न स्थिति है या उन्हें भिन्न कामों का आवंटन किया गया है और इसी आधार पर उन्हें समाज में विशेष शक्तियां और अधिकार मिले हैं। विश्लेषण के एक उपकरण के रूप में लिंग (जेंडर) महिलाओं की स्थिति की स्वाभाविकता और सर्वव्यापकता के दावे को नकारने में मदद करता है। इस प्रकार नारीवादी अध्ययनों में सेक्स और जेंडर अर्थात जैविक पहचान और सामाजिक स्थिति में एक अंतर बनाये रखने का प्रयास किया जाता है। आगे के वर्णन में हम यह देखेंगे कि यह विभाजन हमेशा सभी

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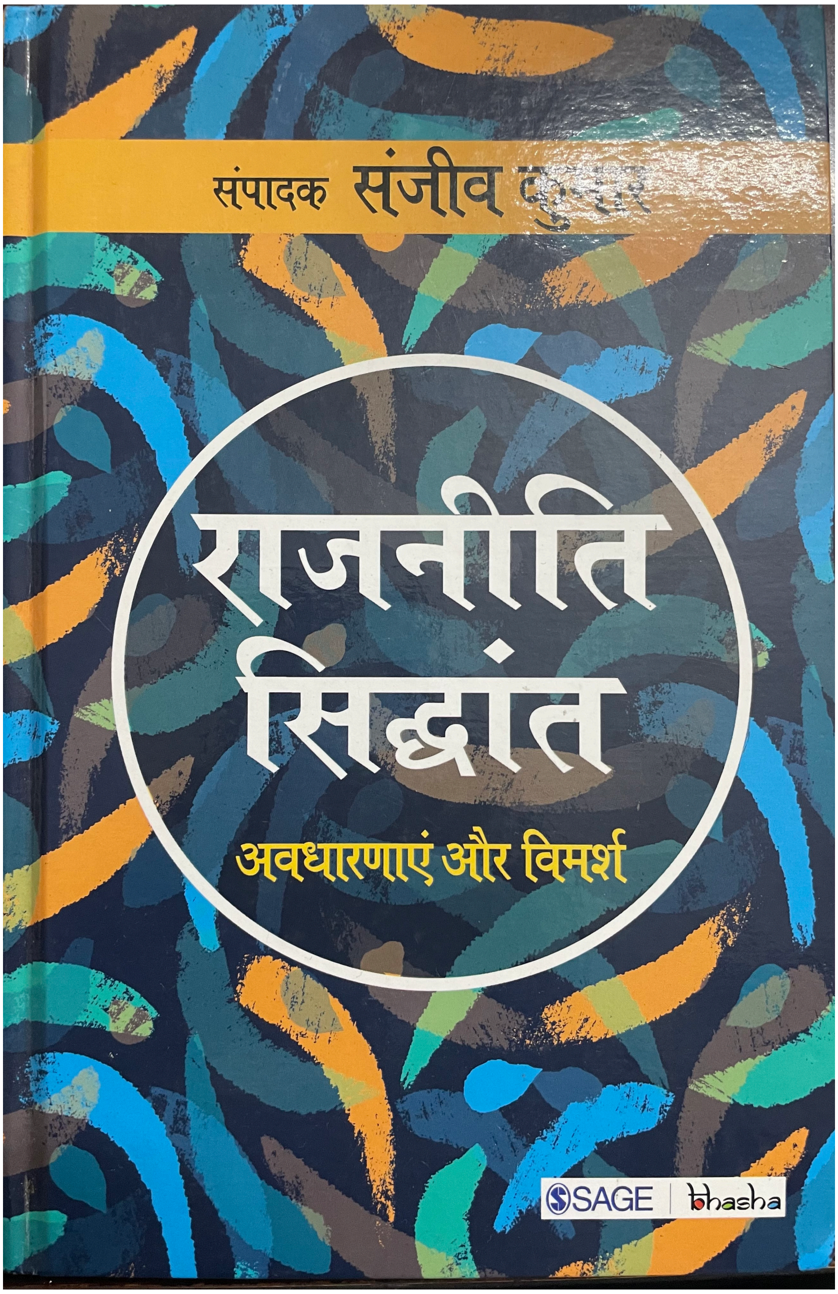
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SAGE | bhasha
SAGE Publications India Pvt Ltd
B1/I-1 Mohan Cooperative Industrial Area
Mathura Road, New Delhi 110 044, India
www.sagepub.in

Published by Vivek Mehra for SAGE Publications India Pvt Ltd. Typeset in 13/15 pt Kokila by AG Infographics, Delhi.

ISBN: 978-93-5388-760-5 (HB)

SAGE Team: Amrita Dutta, Syed Husain Naqvi and Rajinder Kaur

विषय सूचि

FOREWORD BY
Professor Madhulika Banerjee
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Comparative Government and Politics

Edited by
Pushpa Singh
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SAGE Publications Asia-Pacific Pte Ltd
18 Cross Street #10-10/11/12
China Square Central
Singapore 048423

Published by Vivek Mehra for SAGE Publications India Pvt Ltd. Typeset in 9.5/11.5 pt Bookman Old Style by AG Infographics, Delhi.

Library of Congress Cataloging-in-Publication Data

Names: Singh, Pushpa, editor. | Sharma, Chetna, editor.
Title: Comparative government and politics / [edited by] Pushpa Singh, Chetna Sharma.
Description: New Delhi, India; Thousand Oaks, California: SAGE Publications India Pvt Ltd, 2019. | Includes bibliographical references and index.
Identifiers: LCCN 2019014678| ISBN 9789353285692 (pbk.) | ISBN 9789353285715 (e-pub 2.0) | ISBN 9789353285708 (e-book)
Subjects: LCSH: Comparative government. | Postcolonialism. | Developing countries–Politics and government. | Comparative government–Case studies. | Postcolonialism–Case studies. | Developing countries–Politics and government–Case studies.
Classification: LCC JF60 .C55 2019 | DDC 320.3–dc23 LC record available at https://lccn.loc.gov/2019014678

ISBN: 978-93-532-8569-2 (PB)

SAGE Team: Amit Kumar, Indrani Dutta, Vandana Gupta and Kanika Mathur

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مرتب: ڈاکٹر عبدالملک رسول پوری

اسسٹنٹ پروفیسر شعبہ عربی، دہلی یونیورسٹی، دہلی

سن طباعت: ۲۰۲۲ء

صفحات: ۸۱۶

قیمت: ۵۰۰/- روپے

ناشر: الجمعیۃ بک ڈپو، جمعیۃ بلڈنگ گلی قاسم جان، دہلی-۶

آئی ایس بی این: ۹۷۸-۸۱-۹۵۲۲۶۴-۱-۲

Tazkira

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Complied by:

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University of Delhi. Delhi-6

Year of Edition 2022
Pages: 816
Price: 500/-
ISBN: 978-81-952264-1-2

Published By:
Al Jamiat Book Depot
Jamiat Building, Gali Qasimjan, Ballimaran Delhi06

Printed at:
Nice Printing Press .A-33/3A Industrial Area
Sahibabad, Ghaziabad (UP)

تذکرہ

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الجمعیة بکڈپو

جمعیۃ بلڈنگ، گلی قاسم جان، بلی ماران، دہلی-۶

نام کتاب: تذکرہ مولانا معزالدین احمد گونڈوی

مرتب: ڈاکٹر عبدالملک رسول پوری

اسسٹنٹ پروفیسر شعبہ عربی، دہلی یونیورسٹی، دہلی

سن طباعت: ۲۰۲۲ء

صفحات: ۸۱۶

قیمت: -/۵۰۰ روپے

ناشر: الجمعیۃ بک ڈپو، جمعیۃ بلڈنگ گلی قاسم جان، دہلی-۶

آئی ایس بی این: ۹۷۸-۸۱-۹۵۲۲۶۴-۱-۲

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Jamiat Building, Gali Qasimjan, Ballimaran Delhi06

Printed at:
Nice Printing Press .A-33/3A Industrial Area
Sahibabad, Ghaziabad (UP)

خاصانِ خدا کے علوم ومعارف

تالیف

سیدجمال الدین محمد العیدروسی

ترجمہ

ڈاکٹر عبدالملک رسول پوری

تفصیلات

نام کتاب: إيضاح أسرار علوم المقربين

تالیف : سید جمال الدین محمد العیدروسی

ترجمہ : ڈاکٹر عبدالملک، استاذ شعبہ عربی ذاکر حسین دہلی کالج، دہلی یونیورسٹی، دہلی

اشاعت: باراول:۲۰۱۶ء باردوم:۲۰۲۰ء

صفحات : ۳۵۰ قیمت : ۳۰۰روپیہ

آئی ایس بی این: ۹۷۸-۸۱۹۵۳۸۴۸-۴-۶

Khasan e Khuda ke Uloom O Ma'arif

Authored by:*Sayed Jamaluddin Muhammad. Al aidroosi*

Translated by: *Dr. Abdul Malik*

Assistant Professor, Dept of Arabic, ZHDC, Uiversity of Delhi.

Year of Publication

1st Edition: 2016

2nd Editioin: 2022

Pages: 350

Price: Rs:300

ISBN: 978-81953848-4-6

Published by:

Azra Book Traders

2861, Kucha Cheelan, Darya Ganj, New Delhi-02

Printed at:

Nice Printing Press, A-33/3A Industrial Area

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ISBN: 978-93-90568-05-5
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نام کتاب	:	معمارانِ نقدِ قصیدہ
مصنف وناشر	:	محمد معین الدین
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☆ایجوکیشنل بک ہاؤس، یونیورسٹی مارکیٹ، علی گڑھ۔
☆اسریٰ انٹرنیشنل، 915، بلڈنگ نمبر 3، نوجیون سوسائٹی، ممبئی سنٹرل، ممبئی۔ نمبر 8 M. 9930538115

Distributor

EDUCATIONAL PUBLISHING HOUSE

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नेट/जे.आर.एफ. (यू.जी.सी) –बीएड (महर्षि दयानन्द विश्वविद्यालय)

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1. ''साम्राज्यवाद-विरोध, आलोचना और रामविलास शर्मा'' 2012
2. ''डॉ. नगेन्द्र व्याख्यान माला सहित और समाज का अंतसम्बध'' 2015
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सम्प्रति:जाकिर हुसैन महाविद्यालय, दिल्ली विश्वविद्यालय। (अतिथि)

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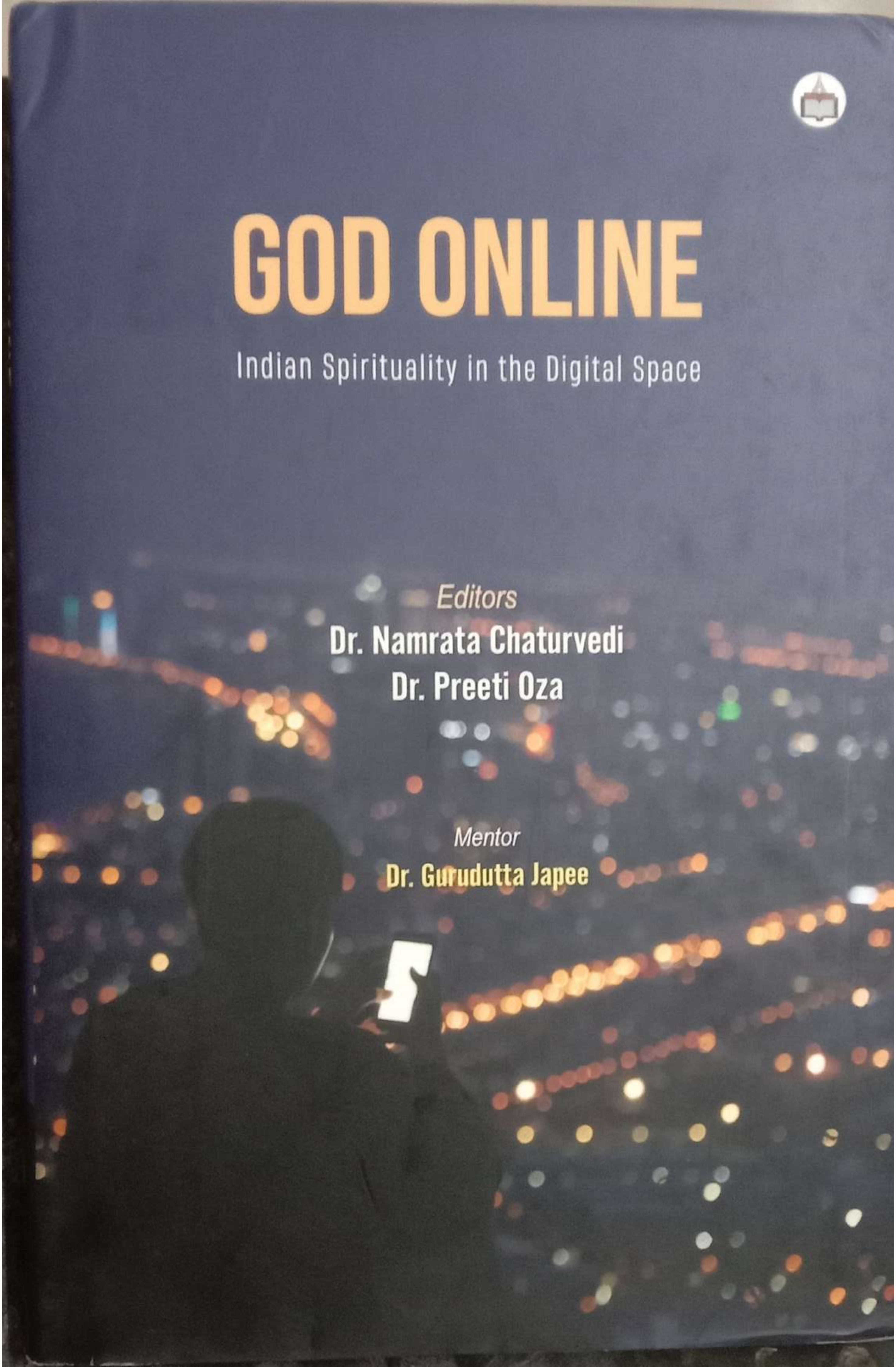
Author: **Dr. Chandrakala prajapati**
Title:**muktibodh aur raghuvir sahay**
Edition:**2021**
Page:**196**

ISBN 978-93-91916-29-9
9 789391 916299

₹ 850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Indian Spirituality in the Digital Space
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epistemologische Doppelleben der Spur." *Spur: Spurenlesen als Orientierungstechnik und Wissenskunst*, ed. Sybille Krämer, et al. Frankfurt: Suhrkamp, 2008, pp. 155-181.
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Seltzer, Mark. "Wound Culture: Trauma in the Pathological Public Sphere." *October*, vol. 80, The MIT Press, 1997, pp. 3-26, https://doi.org/10.2307/778805.

"*An Improbable Possibility*": Deciphering the Female Serial Killer in *Bones Never Lie*

TANYA LAHON WARJRI

Kathy Reichs's *Bones Never Lie* (2014) is the sequel to her novel *Monday Mourning*, which was published a decade earlier. The narrative picks up ten years after the "Pomerleau-Catts reign of terror" (Reichs 167) and explores the subsequent aftermath of their rampage, that is "a return to unfinished business."[1] Forensic anthropologist, Temperance Brennan, is enlisted by the Charlotte PD's Cold Case Unit to go over a case in which Anique Pomerleau's DNA has been identified, indicative of the fact that she has resurfaced. A task force consisting of Brennan, Sûreté du Québec detective Andrew Ryan, Charlotte detective Erskine Slidell, and detective Umparo Rodas from Vermont is set up to track the perverse serial killer's whereabouts.

This work of forensic crime fiction compels its readers to examine the broader issues of society by tracing the actions and development of the antagonist female serial killer, Tawny McGee. The social dysfunctionality displayed by McGee exposes a society unable to reassimilate a 'disturbed' and traumatised individual who was preyed on by predators whose modus operandi would include abduction, rape, torture, and finally murder. McGee was the sole survivor of the carnage carried out by Pomerleau-Catts, having been rescued at the end of *Monday Mourning*, after enduring five years of their depravity. Though the text does not provide readers with a sufficient explanation regarding McGee's operations, stating "One day we may learn how she overcame her former captor, how she harvested Pomerleau's tissues, how she killed her. Or we may not. That will be up to McGee" (Reichs 440), it delivers what is promised by the genre-societal order that is disrupted by the corrupting figure of the serial killer, and is restored by

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A volume in the Advances in Higher Education and Professional Development (AHEPD) Book Series

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Chapter 3
Digital Transformation of Higher Education in India

Shivani Abrol
Zakir Husain Delhi College, University of Delhi, India

Mukesh Kumar Jain
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ABSTRACT

Education was one of the first sectors to experience the consequences of COVID-19. To address this issue, institutions of higher education have changed to an online communication platform, setting up a new standard and redefining the profile of learning for coming generations. The epidemic has fastened the restructuring of higher education, propelling it further toward Education 4.0. Additionally, NEP 2020 includes several reformative measures that are a step in the correct direction. The NEP demonstrates a comprehensive predisposition toward innovative approaches by addressing issues of equity, inclusion, accessibility, exploratory, and experimental learning, all of which are necessary components for transitioning into Education 4.0 and beyond. Education's future may be a synthesis of transformations prompted by Education 4.0, NEP 2020, current pandemics, rising student requirements, and the latest technology. This chapter has attempted to examine some of the most important issues in higher education in today's era and tried to make pertinent recommendations.

DOI: 10.4018/978-1-6684-4083-4.ch003

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FAMILY OWNED BUSINESS AND CORPORATE GOVERNANACE

Dr. Abdul Wahid Farooqi
Assistant Professor, Department of Commerce, Zakir Husain Delhi College, University of Delhi

OBJECTIVES

After studying this chapter, students will be able to

- Understand the meaning of Ethics, Governance and Corporate Social Responsibility
- Know the features and nature of family business
- Learn the problems and challenges of family business
- Understand the challenges and issues of Corporate governance in family owned business
- Know the relevance of Corporate Social responsibility in family business

MEANING OF BUSINESS ETHICS:

Generally, business ethics means equal and fair treatment of all stakeholders of the business. Ethics are basically code of conduct of doing a particular task. In business point of view, business ethics are moral was of carrying business activities or operations. It includes high degree of loyalty, honest, quality, justice and compliance of various business norms. Business activities are carried out within the prescribed limits of the Society. Ethics is concerned with study of morality and the application of reason to expound explicit conventions and principles that establish right or wrong for a given situation, hence generating its theories from the same. It is a conscious stepping back and reflecting on morality. (Crane, Andrew and Dirk Matten). Therefore ethical values are based on morality. For the better understanding of business ethics, it is relevant to know the relationship between ethics and morality. Ethics is the subject that concerned with what is right and what is wrong within the set limits of moral obligation and responsibilities. Whereas morality is a set of principles, values and norms which are universally accepted by the society as a whole. It signifies the principles that in individual or group has about the rightness and wrongness of the act.

The moral definition of Business Ethics is "It is specialized study of moral rights and wrong' [Fleming]. Practical definition of Business Ethics is "Business Ethics is the art and discipline of applying ethical principles to examine and solve complex moral dilemmas (Good plaster).

Through the concept of ethical responsibility of family business, the relationship between family business and CSR (Corporate Social Responsibility) can be examined effectively. Every family business has an ethical responsibility to each of its stakeholder's viz. Shareholders, suppliers, employees, customers, bankers and community in general

MEANING OF CORPORATE SOCIAL REPSONSIBILITY

CSR is generally philanthropic activity of a corporate or business concern. CSR is voluntary activity rather than legal or mandatory obligation. There is sufficient legal provisions and regarding CSR in Companies Act 2013.

CSR consist of four Important areas: -

1. Corporate Financial Responsibility
2. Corporate Governance
3. Corporate Environmental Responsibility
4. Corporate Disclosure Responsibility

First Impression: 2020

Family Business Management

ISBN : 978-81-946375-5-4

Rs. 650/- ($18)

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Published by:
Empyreal Publishing House

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Some units have been adapted from existing IGNOU material

Cover Design: Mr. Tamal Basu, IGNOU panel

PRINT PRODUCTION

Mr. Tilak Raj
Assistant Registrar
MPDD, IGNOU, New Delhi

February, 2022

ISBN : 978-93-5568-351-9

Further information on the Indira Gandhi National Open University (IGNOU) courses may be obtained from the University's office at Maidan Garhi, New Dehi-110068

Printed and published on behalf of the Indira Gandhi National Open University, New Delhi, by the Registrar, MPDD, IGNOU.

Printed at :Raj Printers, A-9, Sector B-2, Tronica City, Loni (Gzb.)

MPDD/IGNOU/P.O. 1K/February, 2022

ISBN : 978-93-5568-351-9

Bahirbange Banglar Udbastu
Edited by Nandita Basu

প্রথম প্রকাশ জানুয়ারি ২০২২

প্রকাশক
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গা ঙ চি ল
'মাটির বাড়ি', ওঙ্কার পার্ক, ঘোলাবাজার, কলকাতা ৭০০ ১১১
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কলেজ স্ট্রিট মার্কেট (বর্ণপরিচয়, দোতলা), স্টল নং সি (পি) ৬, কলকাতা ৭০০ ০০৭
ফোন ৯৪৩২৪ ০৭৬৬৫, ৯৪৩২৯ ৯১৫৩০, ০৩৩ ২২৪১ ০৪০৪ (১--৭)

মুদ্রক
এস পি কমিউনিকেশনস ৩১বি রাজা দীনেন্দ্র স্ট্রিট, কলকাতা ৭০০ ০০৯

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রূপায়ণ সন্তোষ দত্ত

ISBN 978-93-90621-21-7

দাম ৪৫০ টাকা

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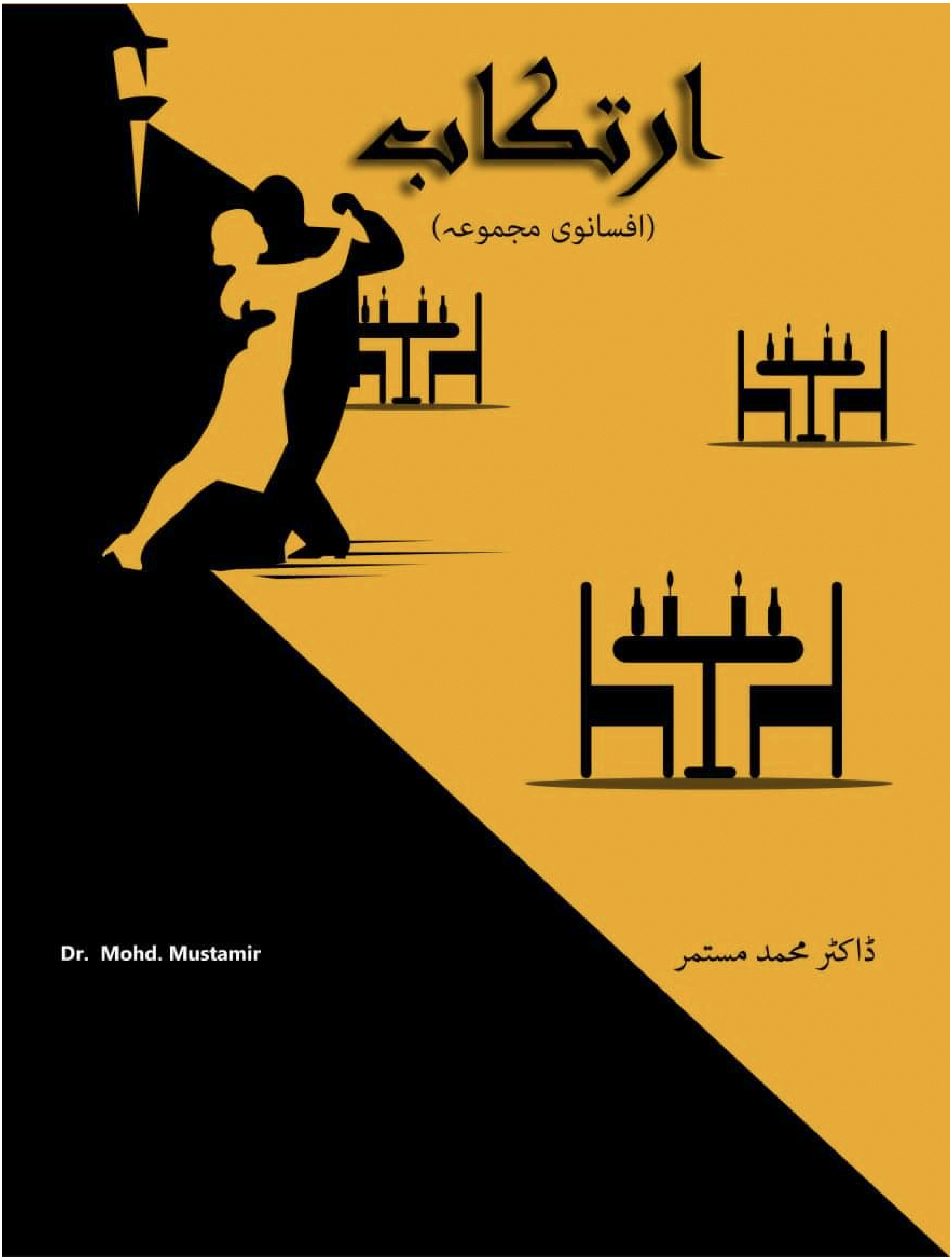
হিমাদ্রীশেখর হাওলাদার

ভারতবর্ষের ইতিহাসের দিকে চোখ পড়লে দেখতে পাওয়া যায় অসংখ্য ক্ষতচিহ্ন। এই ক্ষত কখনও দেশি আবার কখনও বিদেশি সাম্রাজ্যের দ্বারা আঁকা কলঙ্কের ইতিহাস— যা বিভিন্ন সময়ে ঘটা সামাজিক, রাজনৈতিক, ধর্মীয়, অর্থনৈতিক আবার জাতিগতভাবে। আজ যা স্থান পেয়েছে ইতিহাসের পাতায় ও জাদুঘরে। আর সব থেকে বেশি হয়েছে বৈচিত্রময় বাংলায়। এমন কোনও শতাব্দী নেই যে আক্রমণ ঘটেনি, বাংলার মানুষ বিচ্ছিন্ন হয়নি। বাংলার সাধারণ মানুষের ওপর বিচ্ছিন্নতার চরম নিদর্শন গত শতাব্দীর বাংলাভাগ। যার ক্ষত এখনও সেরে তো ওঠেনি, বরং এখনও জ্বলছে তুষের আগুনের মতো ধিক-ধিক করে। বাংলায় তথা বাঙালি হয়ে জন্মানো এখন অন্য ভারতীয়দের হিংসার কেন্দ্র হয়ে দাঁড়িয়েছে। আজ বাঙালিকে দেখলেই অন্যরা হিংসায় জ্বলে ওঠে। আবার ভারতবর্ষে সব থেকে বেশি অবদান এই বাঙালির।

বাংলাভাগের ষড়যন্ত্র ইংরেজরা করলেও তা বাস্তবায়িত করেছে ভারতীয়রা। যার ফলে ১৯৪৭ সালে ঘটে যাওয়া বাংলাভাগ ইতিহাসের পাতায় কলঙ্কজনক অধ্যায় হিসেবে বিবেচিত। আবার সেটারই পুনরাবৃত্তি হয়েছে ১৯৭১ সালের ভারত-পাক যুদ্ধে। এই ভাগের শিকার হয়েছে সাধারণ মানুষ। যারা দূর-দূরান্তেও এর আগে-পিছে জড়িয়ে ছিল না, তবুও ভুক্তভোগী সাধারণ মানুষ। এর পরিণতিতে ঘটেছে খেটে খাওয়া মানুষের দেশান্তর। তারা বাপ-দাদার ভিটে মাটি ছেড়ে হয়েছে ছিন্নমূল। আজও তারা ভারতের বিভিন্ন


ارتکاب
(افسانوی مجموعہ)
Dr. Mohd. Mustamir
ڈاکٹر محمد مستمر

نام کتاب	:	ارتکاب
مُصنف وناشر	:	ڈاکٹر محمد مستمر
قیمت	:	150/روپے
ضخامت	:	160/صفحے
تعداد	:	چارسو
کمپوزنگ	:	مسرت جہاں
سرِ ورق آراستہ	:	حسین وسیم، چنڈی گڑھ
تصورِ سرِ ورق	:	خود ذہنی اختراع
سنِ اشاعت	:	2020ء
مطبع	:	نعمانی پرنٹنگ پریس، لکھنؤ
رابطہ	:	09023746092, 09877432498
پتا	:	محلّہ: اکرام، پنجابی چوک، تحصیل: رامپور منیہاران، ضلع: سہارنپور (یوپی)۔ 247451

mohdmustamir@gmail.com

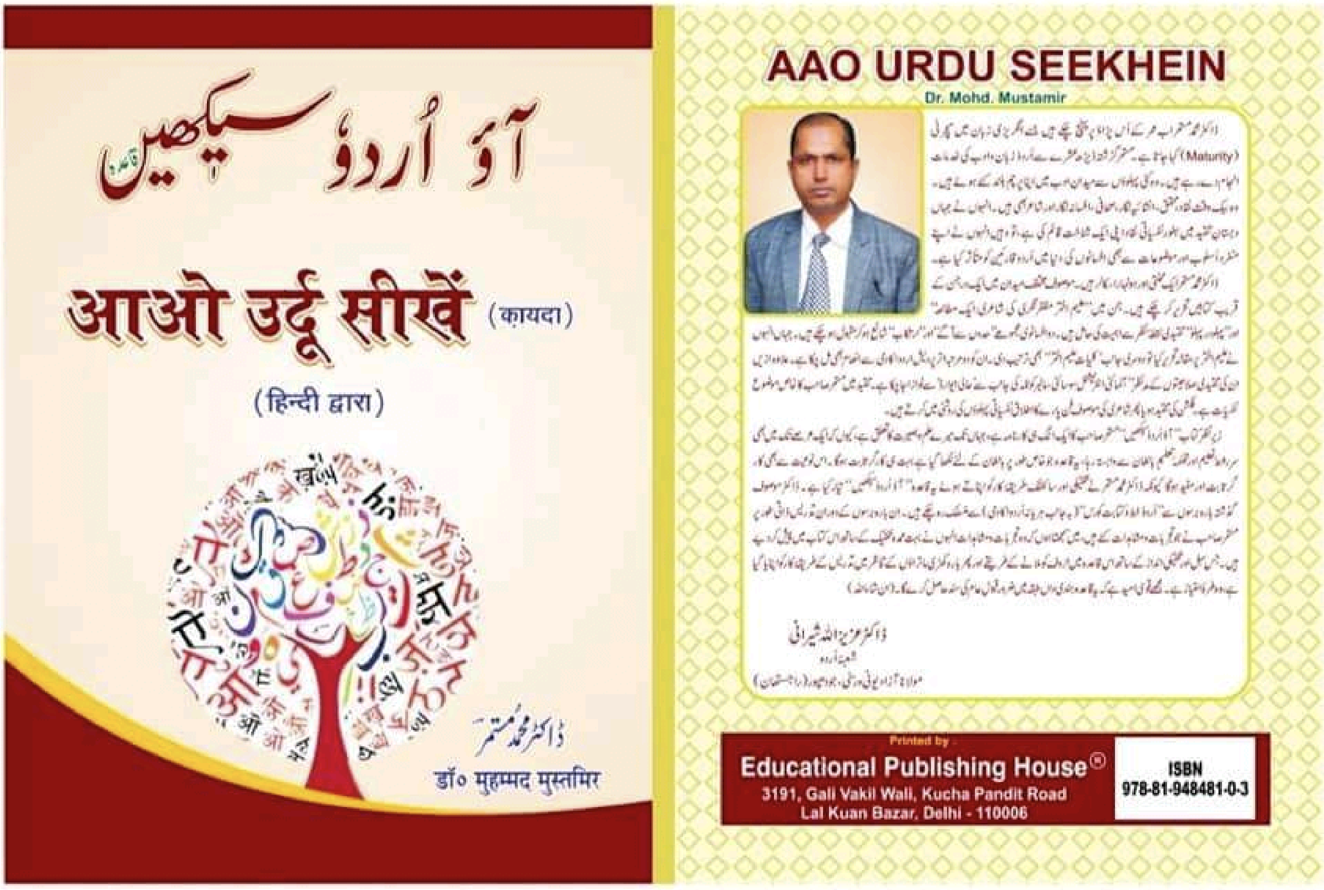
ISBN 935361627-1

9789353616274

ملنے کے پتے:

دانش محل، امین آباد، لکھنؤ226018

محلّہ اکرام، پنجابی چوک، تحصیل: رامپور منیہاران، سہارنپور، (یوپی)۔ 247451


آؤ اردو سیکھیں (قاعدہ)
आओ उर्दू सीखें (कायदा)
(हिन्दी द्वारा)
ڈاکٹر محمد مستمر
डॉ० मुहम्मद मुस्तमिर
AAO URDU SEEKHEIN
Dr. Mohd. Mustamir
Printed by :
Educational Publishing House®
3191, Gali Vakil Wali, Kucha Pandit Road
Lal Kuan Bazar, Delhi - 110006
ISBN
978-81-948481-0-3

نام کتاب : آؤ اُردو سیکھیں (قاعدہ)

مصنف : ڈاکٹر محمد مستمر

تعداد : پانچ سو

کمپوزنگ وتزئین کاری : محمد زبیر (Mob.: 9045757718)

سنِ اشاعت : 2020ء

مطبع : روشان پرنٹرس، دہلی۔٦

ISBN : 978-81-948481-0-3

زیرِ اہتمام

انسانی حقوق ویلفیر ٹرسٹ

मानव अधिकार वेलफ़ेयर ट्रस्ट

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ملنے کے پتے

ایجوکیشنل پبلشنگ ہاؤس، دہلی-6

مکتبہ جامعہ لمیٹڈ، اردو بازار، جامع مسجد، دہلی-6

ارحان پرنٹرس، سٹی گارڈن

تھانہ بھون ضلع شاملی (یوپی) -247777

क़ीमत : 150.00

قیمت : 150/روپئے

सम्पर्क सूत्र : 9023746092 : رابطہ

Published by :

EDUCATIONAL PUBLISHING HOUSE

H.o. D 1/16, Ansari Road, Darya Ganj, New Delhi-110002 (INDIA)
B.o. 3191, Vakil Street, Kucha Pandit, Lal Kuan, Delhi - 6 (INDIA)
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डॉ. मुहम्मद मुस्तमिर को मैं तब से जानता हूँ जब वे उर्दू साहित्य में नए–नए आए थे। सबसे पहले मैं उनकी लिखाई की सुंदरता से प्रभावित हुआ था। उसके बाद धीरे–धीरे मुझे अहसास होता गया कि मुहम्मद मुस्तमिर एक ऐसा विद्यार्थी है जो प्रतिभा का धनी है, अगर इस पर महनत की जाए तो यह बहुत आगे जा सकता है। उस्ताद के लिए भी यह खुश क़िस्मती की बात होती है कि उसको एक ज़हीन, कुशल और महनती विद्यार्थी मिले।

डॉ. मुहम्मद मुस्तमिर का साहित्यिक सफ़र लगभग डेढ़ दशक पर आधारित है। इन डेढ़ दशकों में इन्होंने साहित्य के विभिन्न क्षेत्रों में अपनी प्रतिभा का प्रदर्शन किया है। जहां इन्होंने निबंध और आलोचनात्मक एवं शोधात्मक लेख लिखे तथा एक दर्जन पुस्तकों की रचना की तो उसी के साथ साथ इन्होंने उर्दू फ़िक्शन में भी अपने जौहर दिखाए। अब तक इनके दो कहानी संग्रह ' हदों से आगे' और 'इरतिकाब' उर्दू भाषा में प्रकाशित हो चुके हैं। प्रथम कहानी संग्रह को उत्तर प्रदेश उर्दू अकादमी से भी सम्मानित किया गया। डॉ. मुहम्मद मुस्तमिर कुछ लीक से हटकर भी करने की धुन में लगे रहते हैं। इन्होंने अब से पहले दो हिंदी छंद मुक्त कविताओं का उर्दू में बहुत ही खूबसूरत अनुवाद किया है, बरगद की जड़ें और इरतिआश। हाल फ़िलहाल मशहूर फ़िक्शन राइटर कश्मीरी लाल ज़ाकिर का मशहूर नाविल जो एड्स के विषय पर आधारित है यानी 'आख़िरी अध्याय' का अनुवाद किया है। 'आख़िरी अध्याय' उपन्यास बहुत ही संवेदनशील, करुणा पूर्ण और ह्रदय की आंतरिक गहराइयों में उतर जाने वाला उपन्यास है जो दुखांत उपन्यास की श्रेणी में आता है। आरम्भ से लेकर अंत तक गौतम के दुखों की कहानी को बयान करता है। गौतम के साथ ही श्रद्धा इस उपन्यास की मुख्य पात्र है।

डॉ. मुहम्मद मुस्तमिर ने कश्मीरी लाल ज़ाकिर के इस उपन्यास का सरल और सुन्दरता के साथ अनुवाद किया है। मैं इस मौक़े पर डॉ. मुहम्मद मुस्तमिर को मुबारकबाद देता हूँ कि इन्होंने अपने अथक प्रयासों से इस उपन्यास का निष्ठापूर्वक अनुवाद किया है। मेरी शुभकामनाएं और दुआएं उनके साथ हैं।

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दिल्ली विश्वविद्यालय, दिल्ली।

ISBN 978-93-90789-00-0
www.ephbooks.com

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PUBLISHING HOUSE
New Delhi , INDIA

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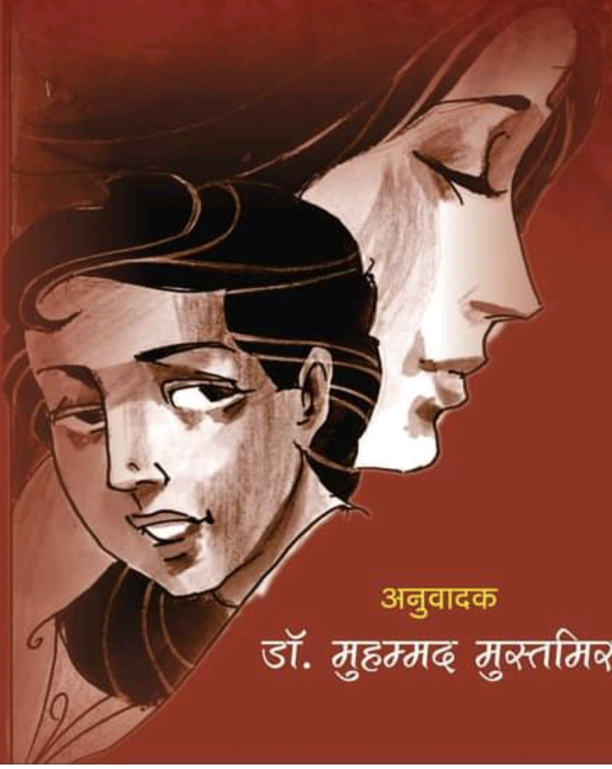

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डॉ. मुहम्मद मुस्तमिर

यह पुस्तक हरियाणा साहित्य अकादमी पंचकूला के आर्थिक सहयोग से प्रकाशित हुई है।

लेखक का नाम	:	कश्मीरीलाल जाकिर
अनुवादक	:	डॉ. मुहम्मद मुस्तमिर
मूल्य	:	रु0 200
कम्पोज़िंग	:	जटिल कश्यप
प्रकाशन वर्ष	:	2020 ई०
संख्या	:	500
पता	:	हरियाणा उर्दू अकादमी, आई.पी. 16, सेक्टर–14, पंचकूला–134113
सम्पर्क सूत्र	:	9023746092
ई–मेल आई डी	:	mohdmustamir@gmail.com

Distributor

EDUCATIONAL PUBLISHING HOUSE

H.o. D1/16, Ansari Road, Darya Ganj, New Delhi-110002 (INDIA)
B.o. 3191,Vakil Street, Kucha Pandit, Lal Kuan, Delhi-6 (INDIA)
Ph: 45678285, 45678286, 23216162, 23214465, Fax : 0091-11-23211540
E-mail: info@ephbooks.com,ephindia@gmail.com
website: www.ephbooks.com

विषय सूचि

संपादक संजीव कुमार

राजनीति सिद्धांत

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6 राजनीतिक बाध्यता

शबाना आजमी

प्रस्तावना

मानवीय समाज में मनुष्य जीवन कई प्रकार के संबंधों पर आधारित होता है। इन संबंधों का ताना-बाना एक मनुष्य से दूसरे मनुष्य के बीच, मनुष्यों और समाज, राज्य और कई और संस्थानों के बीच, या सरल शब्दों में समझा जाए तो मनुष्य जिस वातावरण में अपना जीवन व्यतीत करते हैं उस वातावरण से उत्पन्न संबंधों से बनता है। मानवीय समाज में जहाँ ये संबंध जीवन में कई बाधाएँ हटाने में सहायक होते हैं, वहीं इनका निर्वाह करने के लिए मनुष्यों को कई प्रतिबंधों, जो कि नियमों और कानूनों, का रूप लेते हैं, को स्वीकार करना पड़ता है। यह परिस्थिति मानव की मानवीय समूह के साथ संबंध दर्शाती है। लेकिन प्रतिबंधों को मानने के लिए यह तर्क सर्वसम्मत नहीं है। हम सदैव एक व्यक्ति के रूप में यह सोचते हैं कि इस प्रकार के प्रतिबंध व्यक्तियों पर क्यों लगाए जाएँ? हम क्यों किसी की (सत्ता) आज्ञा का पालन करते हैं? यह सवाल न केवल हमारे मन में उजागर होता है बल्कि बहुत से राजनीतिक दार्शनिकों ने इस पर कई सवाल उठाए हैं। राजनीतिक बाध्यता के सिद्धांतों में, व्यक्तियों के परिप्रेक्ष्य से, यह प्रश्न पूछा जाता है कि व्यक्ति की बाध्यता किसके प्रति हो (उसकी व्यक्तिगत चेतना या नैतिकता से, उसके परिवार से या फिर किन्हीं अन्य सामाजिक संस्थानों से जैसे कि धार्मिक संस्थान या फिर राज्य से। इसलिए राजनीतिक बाध्यता को विभिन्न राजनीतिक चिंतक अपने विभिन्न मतों से व्याख्यायित करते हैं। यहाँ प्रश्न यह भी उठता है कि व्यक्ति किसके प्रति बाध्य है--कानून, राजनीतिक सत्ता या नागरिक समाज के ति? राजनीतिक बाध्यता मूल रूप से राजनीतिक दार्शनिकों और सामान्य नागरिकों में एक ुख्य समस्या के रूप में प्रतिबिंबित होती है। यदि एक समस्या के रूप में हम राजनीतिक ाध्यता को देखें तो प्राचीन समय से समकालीन समय तक इस विषय को लेकर एक संचय ा बना हुआ है। जिससे इस विषय पर अभी तक किसी तरह की कोई आम सहमति नहीं न पाई है। इसलिए राजनीतिक बाध्यता की अवधारणा की समझ बहुत व्यापक और टिल प्रतीत होती है। यह अपने आप में बहुत सी संकल्पनाओं को आत्मसात करते हुए लती है। इसकी सामान्यता और अस्पष्टता को देखते हुए थॉमस मैकफर्सन का मानना है क राजनीतिक बाध्यता की संकल्पना को राजनीतिक दर्शन का विषय ही नहीं माना जाना ाहिए। यदि हम इस राजनीतिक बाध्यता की संकल्पना को हटा दें हमें यहाँ यह उचित हसूस हो सकता है क्योंकि यह एक इतनी सामान्य संकल्पना है जो किसी काम की नहीं (मैकफर्सन, 1967, 68)।

This edition published in 2021 by

SAGE | bhasha

SAGE Publications India Pvt Ltd
B1/I-1 Mohan Cooperative Industrial Area
Mathura Road, New Delhi 110 044, India
www.sagepub.in

Published by Vivek Mehra for SAGE Publications India Pvt Ltd. Typeset in 13/15 pt Kokila by AG Infographics, Delhi.

ISBN: 978-93-5388-760-5 (HB)

SAGE Team: Amrita Dutta, Syed Husain Naqvi and Rajinder Kaur

GENDER SECURITY & GLOBAL POLITICS

DR. ANDREY SHASTRI & DR. NANDINI BASISTHA

Copyright © : Reserved

Edition : 2021

ISBN No. : 978-93-5457-955-4

Price : ₹ 2500.00

Published by : **INTERDISCIPLINARY INSTITUTE OF HUMAN SECURITY & GOVERNANCE**

Registered Office - C 144, Sarvodoya Enclave, New Delhi - 110017, India

Branch Office - N19, Hill View Garden, Bhiwadi, Alwar, Rajasthan - 301018, India

Laser Typesetting : Kumar Computer, Delhi

Printed at : Balaji Offset, Delhi - 32

PRINTED IN INDIA

Content

FACULTY
VIEW

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Academic Bank of Credit will promote learning

It will standardise the existing credit system and reduce disparity among institutions by encouraging uniformity

On the completion of one year of National Education Policy (NEP) 2020, PM Narendra Modi launched the Academic Bank of Credit (ABC), a promising policy to internationalise India's higher education system. ABC is a virtual space provided to students to deposit and accumulate their credits which they earn while pursuing courses offered by Indian universities.

As a student-centric initiative, UGC regulation of ABC provides a learning- friendly approach to ensure multidisciplinary, holistic education by allowing for flexibility of curriculum framework and interdisciplinary academic mobility of students across Indian higher educational institutions with appropriate credit transfer mechanism, in order to earn a degree or diploma. There are three major changes that ABC can bring in Indian higher education after its operationalisation. First, it can lead to reduction in dropouts and enhancement in gross enrolment ratio due to freedom and flexibility in university degree granting system, second, standardisation and integration of Indian higher education system and third, internationalisation of Indian higher education.

Best combinations

Due to rigidity in degree granting process, students had to leave the university system due to transferable jobs of their parents or economic and other problems. Now, students may accumu-